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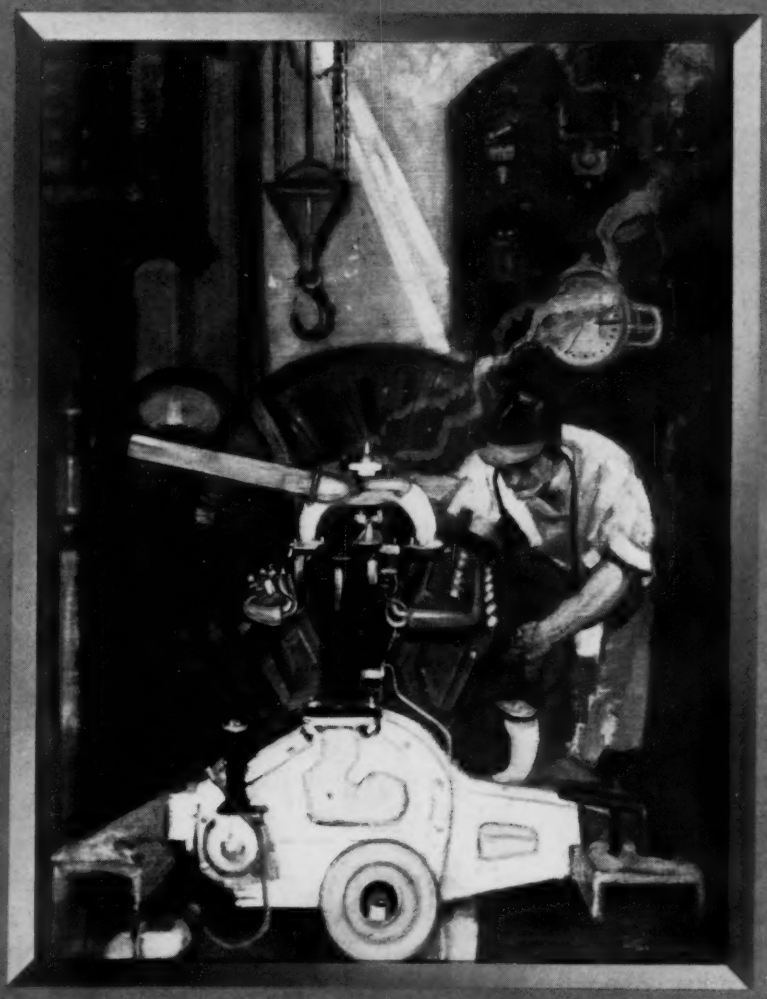

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VOL. VIII, NO. 8 JANUARY, 1928

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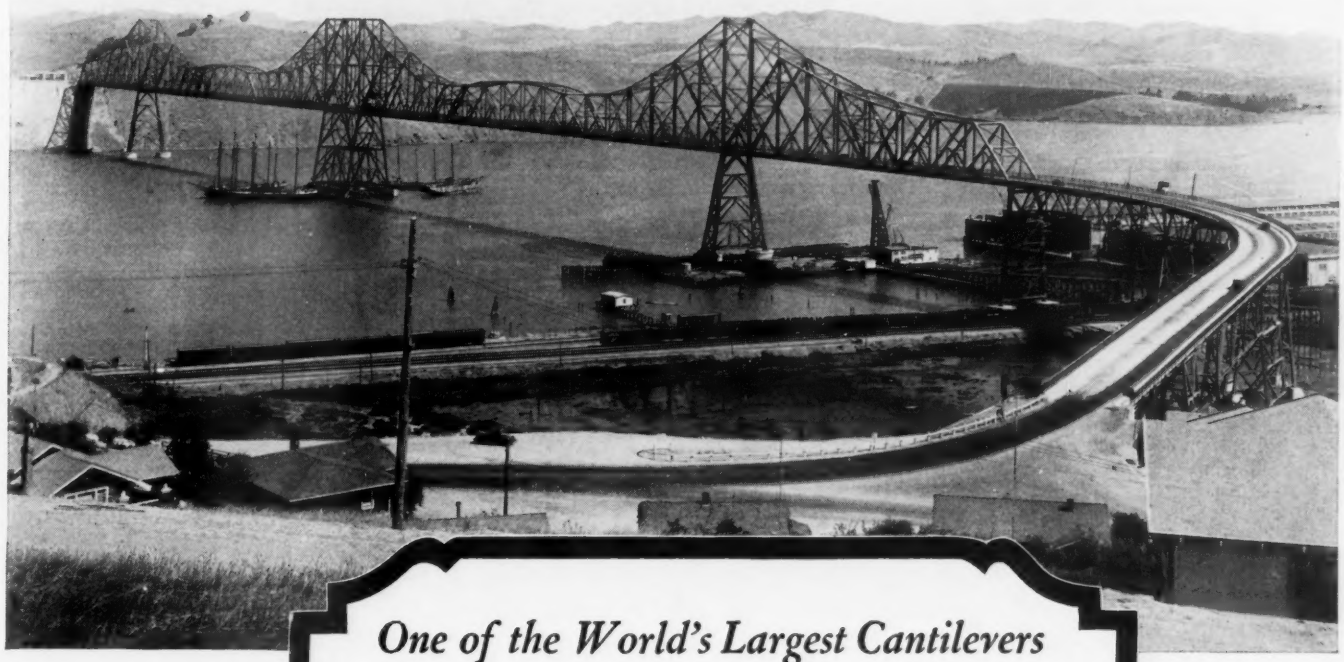
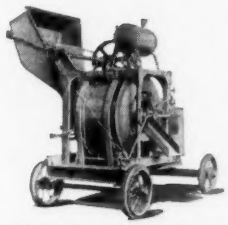


One of the World's Largest Cantilevers

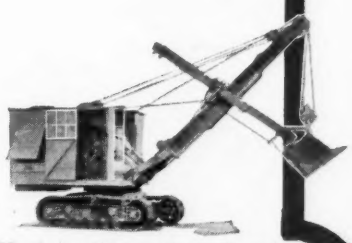
THE new highway toll bridge across Carquinez Strait in California replaces an old historic ferry on the route from San Francisco east and north to Sacramento. It is the cantilever type with two main spans of 1100 feet each, making it the second largest of its kind in the United States and the fourth largest in the world.

The Carquinez bridge is also noted for its deep pier foundations which are 132 ft. below water level with a total height of 440 ft. The total length of the main structure is 3350 ft., including two anchor arms of 500 ft. each and a central tower span of 150 ft.

A Koehring 14S mixer was used in mixing the concrete for the floor of this giant cantilever and a ten year old Koehring mixer did the mixing for the piers —dominant strength concrete for lasting dependability. Three Koehring Heavy Duty Shovels excavated 207,000 cubic yards of material in building the 1.8 miles of the southern approach.



Koehring Heavy Duty Construction Mixer No. 14-S



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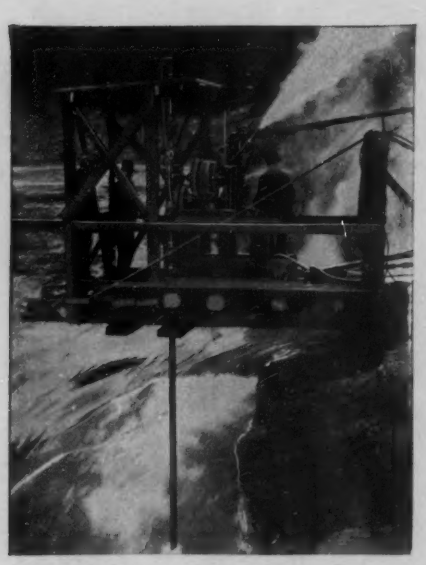
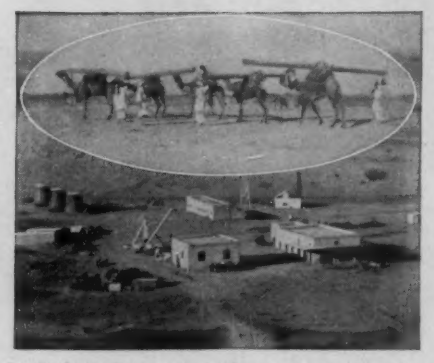
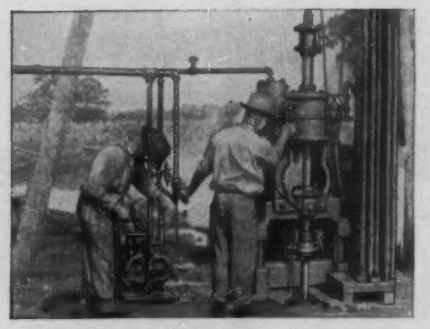


A Sullivan Diamond Drill Testing a dam site at Kettle Falls on the Columbia River



A Sullivan Diamond Drill was transported via camel, 700 miles into central India, to take a core down to 6000 feet in a search for oil



Sullivan Diamond Drill prospecting for coal in Southern Illinois

Sullivan Diamond Drill Boring a 675-Foot Hole, Upwards in a Mexican Mine. At right is a core from oil structure

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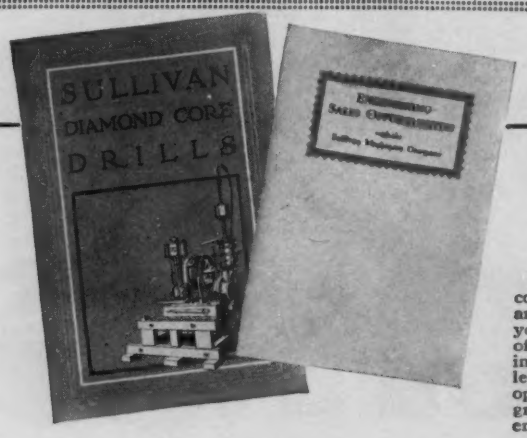

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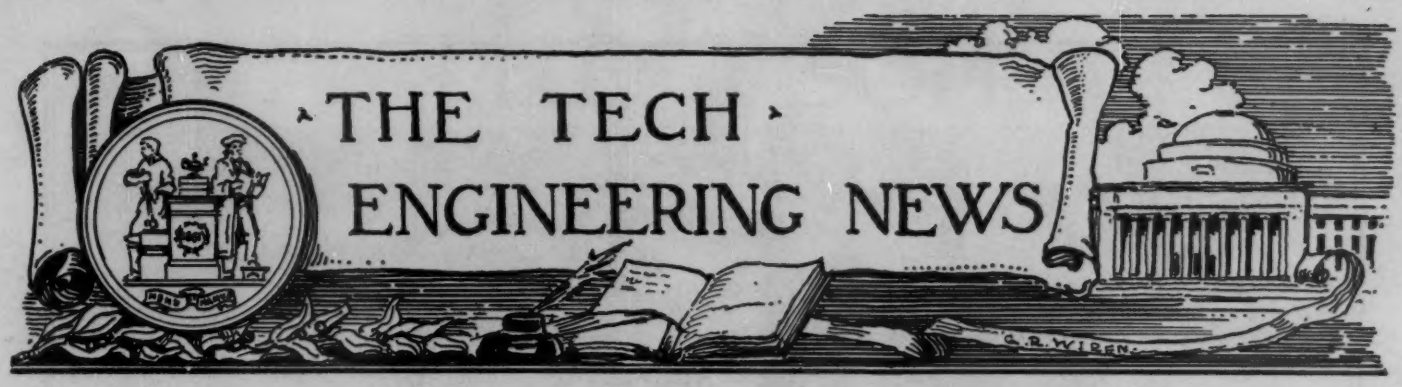

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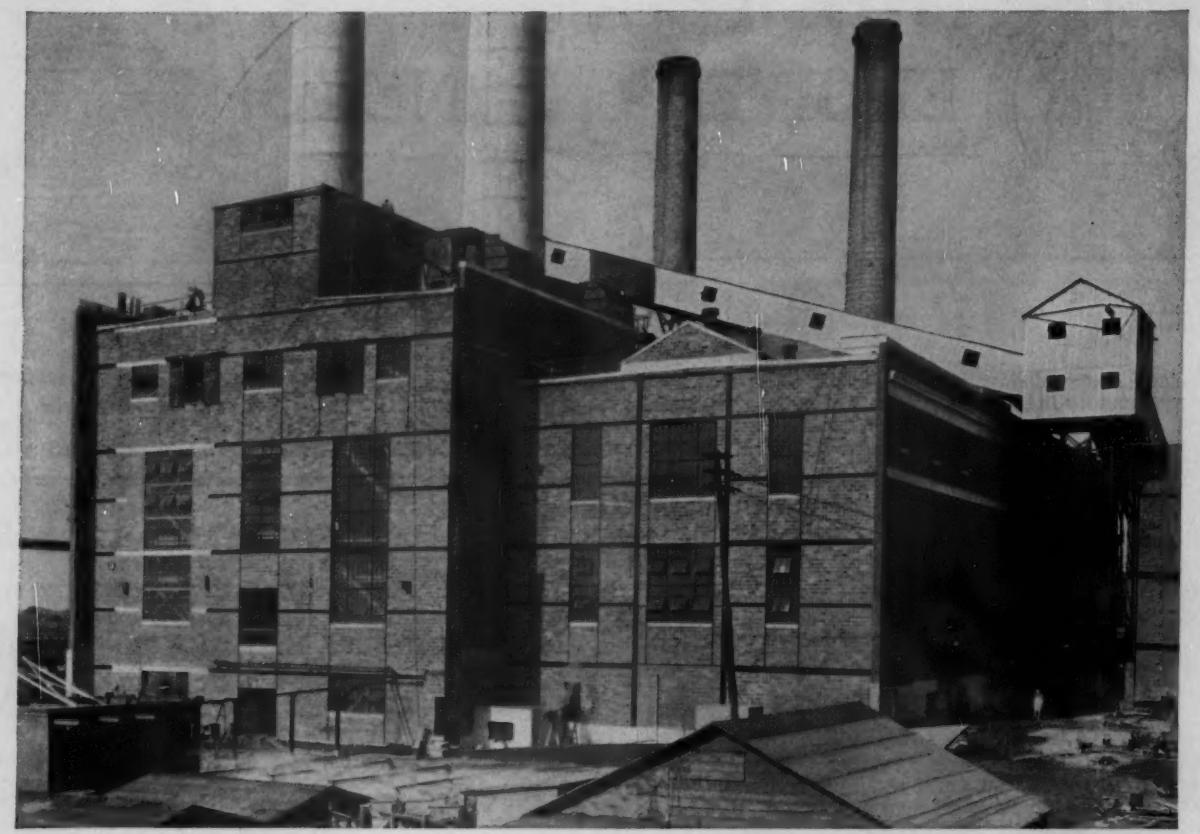

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THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME VIII JANUARY, 1928 NUMBER 8

Theories of Disease Immunity

A description of the processes going on within the body to combat disease and the methods by which we may aid nature in eliminating specific diseases

By FRANCIS H. SLACK, M.D.

Assistant Professor of Public Health Laboratory Methods, Massachusetts Institute of Technology

THE discoveries in recent years relating to the control of communicable diseases have gone far toward establishing this division of public health activity on a firm scientific basis.

Recovery from any infection is accompanied by the presence, in the blood serums of the patient, of certain substances which have been produced by the body cells in response to the attack of the invading organism. These substances are called antibodies and they have a specific action either in neutralizing the poisons produced by the invader or even in bringing about its destruction.

Since such antibodies are manufactured in response to infection, they become available only after a disease has progressed for some time. Any such disease has an incubation period, *i.e.*, a time after infection during which the infective organism multiplies in the body without serious opposition and the patient shows no symptoms of the disease. This is followed by a period of characteristic symptoms accompanied with fever showing that the organisms have become sufficiently powerful to seriously affect the body cells and processes. During both these periods, but especially the latter, the cells of the body are stirred up to manufacture protective substances against the invader and the outcome of the infection is dependent on the balance of the opposing powers which are the virulence of the invading organisms as opposed to the protective mechanism of the host.

Recovery indicates then a superiority of antibodies unfriendly to the invading organism.

With some diseases, such as smallpox or measles, these antibodies become a permanent possession and the recovered person is henceforth immune to that infection; with other diseases, such as pneumonia, the immunity attending recovery is of shorter duration, the antibodies disappear and the person is again susceptible.

It seems probable in large communities that many persons may have slight infections or contacts with germs of infectious diseases which, without a distinct attack of the disease, cause the production of sufficient antibody material for their protection. Thus children of one to five years of age who are extremely susceptible to diphtheria or scarlet fever may as they become older, develop protective immunity without known infection.

In country districts where the personal contacts are not so numerous, older children may remain almost as susceptible as younger ones.

Some diseases, such as measles, have so great infective power that few escape. Even here, however, the constant presence of the disease tends to lighten its severity. If an infective disease is introduced into a country for the first time, it attacks all ages. Under such conditions measles may be a terribly fatal malady sweeping through the entire population.

Chapin believes that such diseases as smallpox and scarlet fever prevail in mild form in the United States at the present time because efficient quarantine of the more severe types has left only the mild and unrecognizable cases of these diseases at large as foci of infection.

An immunity which is produced by the activities of the body cells in response to infection is known as an active immunity and is apt to continue for a considerable period of time.

The first task of preventive medicine then was to find some method for production of specific antibodies without producing the disease. The first great victory along these lines was by Jenner in 1796, when he proved that inoculation with cowpox virus would protect from smallpox (which is one of the most virulent of the communicable diseases). At that time smallpox was the scourge of the world and was a disease of childhood because it was so prevalent that few could reach adult age without contracting it.

Jenner proved that the virus of smallpox, modified by passing through the cow, would on inoculation produce but a single pock and would confer immunity. Thanks to this discovery of Jenner's and to its application, smallpox has become so rare a disease in civilized countries that many physicians never see a case. Indeed, the disease might be banished from the earth. That such a loathsome disease still lurks among us and prevails more extensively in the United States than in almost any country in the world is a shame and a disgrace, the responsibility for which rests squarely upon those misguided faddists who expend their money and energy in opposing vaccination.

Following Jenner's discovery little was done in disease prevention until the time of Louis Pasteur, on whose careful experimental and research work much of our modern knowledge is

based. It was shortly after 1880 when Pasteur developed methods for attenuating the viruses of several animal diseases, and the inoculation of these weakened viruses gave protective immunity. By passing the virus of rabies through rabbits he lowered its virulence for man, and having still further attenuated it by drying the nerve tissues in which it was contained he succeeded by inoculating it into persons bitten by rabid dogs, in preventing the development of the disease. Since that time deaths of human beings from rabies have been very few because of the universal adoption of this harmless preventive treatment. Pasteur also developed successful vaccines for bacterial diseases of animals and birds such as anthrax and chicken cholera.

About 1896 Almroth Wright began experiments on soldiers of the British Army in India to see if typhoid fever might be prevented by inoculating suspensions of killed typhoid bacilli. His results were so promising that the experiments were repeated elsewhere and the technique of preparing the vaccine perfected. In preventing typhoid fever this vaccine has nearly one hundred per cent efficiency and its protective action persists for two or three years after administration. Typhoid fever, formerly one of the worst foes of military camps, was so completely routed by vaccine in the World War that its occurrence was practically negligible.

In city life the disease has disappeared to such an extent that preventive vaccination of the whole population is unnecessary. Those exposed to the disease, such as the immediate family of one becoming ill with it or the nurse who cares for such cases, should be vaccinated. It is also a wise precaution for one about to travel in countries or districts where there may be danger from impure water to take the preventive inoculations.

Bordet & Gengou in 1906 published their discovery of the bacillus causing whooping cough, and at once experiments were begun with vaccines for this disease. The seriousness of whooping cough, especially in young children, is not generally recognized. In the United States registration area the death rate from whooping cough or from its complications is nearly twice that of scarlet fever.

The first experiments with whooping cough vaccine were not promising, chiefly because it was used in too small amounts. Later work is more promising and indicates that vaccination protects against infection and that if vaccinated persons contract the disease they have it in a milder form. Whooping cough vaccine given during the disease is also helpful in lessening its severity.

Experience with bacterial vaccines prove that they are most active and helpful when the organism is least altered in the process of attenuation. In general, the organism should be freshly isolated, not cultured over too long a period, and if killed with heat it should be done at as low a degree as possible. It is believed the earlier typhoid vaccines were less efficacious than those made at the present time because too much heat was used in sterilizing them.

Theoretically, if one could introduce living disease germs without causing infection, it would be the ideal way to stir up the production of protective antibodies.

One of Pasteur's first successful experiments did this very thing. He attenuated anthrax bacilli by growing them at 42°C. instead of the normal optimum temperature of 37°C. Cattle inoculated with these living attenuated organisms did not develop the disease and when later they were inoculated with virulent organisms, in dosage sufficient to cause fatal results in control animals, they suffered no harm.

There are some bacteria which cause disease only when introduction to the body is through certain channels. Such organisms as dysentery bacilli act only through the intestinal tract and are unable to multiply if introduced under the skin. Here, living attenuated cultures have been successfully used for protective vaccination of human beings. As a rule, however, we hesitate to use living bacteria for such purposes on account of possible dangers.

It has also been determined that a certain concentration of bacteria is necessary to cause infection, that one or two or perhaps ten will not suffice but will be overcome by natural protective substances such as the bactericidal power of the blood serum or the phagocytic action of leucocytes.

Barber, in 1907, developed a method for picking up individual bacteria under the microscope by the use of which, if one wished, he could inoculate a single organism. Webb & Williams in 1908, reported experiments with living virulent tubercle bacilli where, by the use of Barber's method of counting, rabbits and guinea pigs were immunized by inoculating increasing doses of these living organisms, some receiving finally as many as 140,000 without developing the disease. In 1911 they applied this method to two children three months and three years of age. These children were constantly exposed to tuberculosis and it was thought best to attempt immunity production by carefully graded doses rather than have them suffer almost certain infection from irregular and larger amounts naturally received.

Many investigators have reported the production of immunity in animals by the use of attenuated tubercle bacilli. The latest and most extensive human experiments along this line are by Calmette & Guerin in France, 1924–25–26, who have attenuated cultures of tubercle bacilli of bovine origin by passing them through over 200 sub-inoculations on a special medium reducing their infective power to zero even when living cultures are inoculated into calves. These living cultures were then fed to babies, whose surroundings were such that they could hardly escape natural infection, in doses of 500,000,000, three such doses being given at 48-hour intervals on the third, fifth and seventh days after birth. Over 11,000 children received this living tubercle bacillus vaccine from July, 1924 to July, 1926. It is, of course, too early to draw conclusions from these tests.

Dr. Petroff of the Trudeau laboratory, New York, believes there is still a question whether such bacteria may not regain their virulence after entering the body and that it is safer to work with killed tubercle bacilli or their products and that "dead tubercle bacilli or some of their derivatives can be used safely and effectively for immunizing the human race."

Leaving the question of active immunity, let us go back to the consideration of another development in the protection from and cure of disease which has been of incalculable benefit. About 1890–92, V. Behring and his associates focussed attention on a new and hopeful aspect of this subject. Roux and Yersin had previously shown that diphtheria bacilli do not themselves penetrate the body but cause disease through the production of a soluble toxin or poison which was absorbed.

V. Behring found that by inoculating animals with repeated small doses of this toxin an active immunity against it could be established. He further found, and this is the significant thing, that the blood serum of animals so immunized if drawn off and mixed with the toxin, neutralized it so that susceptible animals inoculated with such a mixture were not affected even though they received many times the fatal dose of toxin. Animals inoculated with fatal doses of toxin alone could be saved by subsequent inoculations of immune serum if not too long delayed.

Such immune serum was named antitoxin and showed remarkable beneficial effects when inoculated early into those suffering with diphtheria. Its manufacture on a large scale, by inoculating horses with the toxin, was soon begun and since 1893 diphtheria antitoxin has been everywhere available. The death rate from this disease has been

(Continued on page 352)

The Transmission of Heat by Gas Radiation

An M. I. T. research which has produced important developments in the theory of radiation from a non-luminous source of heat

By Hoyt C. Hottel

Research Associate, Department of Chemical Engineering, Massachusetts Institute of Technology

THE primary purpose of a furnace is the liberation of heat and its subsequent transfer from the flame. Consequently, in designing such equipment, there is involved a quantitative consideration of heat transfer from a flame or hot gas to a receiving surface. It has but recently been generally realized that radiation from non-luminous gases plays an important role under such conditions and is frequently the controlling factor in heat transmission from a non-luminous flame.

The importance of radiation from gases is best emphasized by a consideration of how heat transmission of this type differs from the more familiar mechanism of conduction and convection. The latter type varies widely with gas velocity and size of gas passage, somewhat with gas temperature, and scarcely at all with gas composition. Heat transfer by gas radiation is independent of gas velocity, varies with the size of apparatus in a manner entirely different from convection heat transfer, and is highly sensitive to a change in temperature. It is obvious, then, that safe extrapolation of plant data on heat-transfer coefficients necessitates the assumption of the proper mechanism of heat transfer. At low temperatures or with thin gas layers heat transfer by gas radiation is negligible. At high temperatures and with thick gas layers it is the controlling factor.

Physicists for a long time have been familiar with the infra-red spectrum of gases, having its origin in changes in energy levels of rotation and of vibration of molecules, capable of thermal excitation. Investigations of the emission and absorption spectra of non-luminous flames and of heated gases, begun by Julius and continued by Paschen and others, have indicated that thermal excitation of the molecules rather than any chemical reaction occurring in a flame is the source of the radiation, at least of so large a fraction of it as to make any radiation due to the reaction itself negligible from an engineering standpoint. These investigations which indicated the nature of radiation from hot gases were more concerned, however, with the resolution of characteristic gas radiations into bands, groups, and families for the purpose of studying molecular structure than in any quantitative determination of the total energy emitted by a gas. Not until the important investigations of Schack*† was there any satisfactory attempt to determine heat transmission by radiation from non-luminous gases. The method of calculation proposed by him involved, however, the separate calculation of radiations within several different wavelength regions for each radiating constituent of the flame or gas. From an engineering standpoint, a simplification of the method was essential. Justification for such simplification has been presented in other papers. (See footnote ‡ and § on page 364.) It is within the province of the present paper to present only those charts essential to heat-transfer calculations, with enough discussion to indicate their use.

Of the gases encountered in heat-transfer equipment, carbon monoxide, the hydrocarbons, water vapor, carbon dioxide, and sulphur dioxide are the only ones

(*Continued on page 356*)

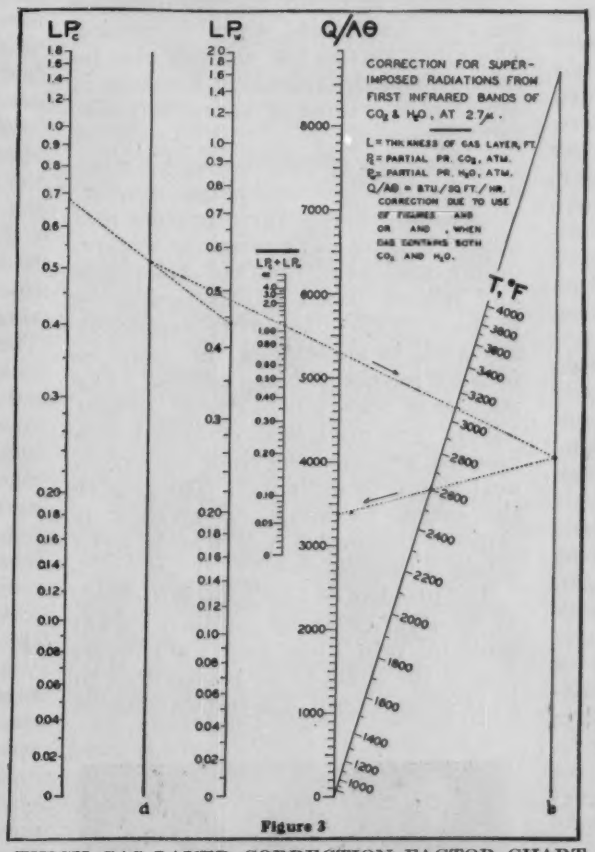

LP_c
LP_w
Q/AΘ
CORRECTION FOR SUPERIMPOSED RADIATIONS FROM FIRST INFRARED BANDS OF CO₂ & H₂O, AT 2.7μ.
L = THICKNESS OF GAS LAYER, FT.
P_c = PARTIAL PR. CO₂, ATM.
P_w = PARTIAL PR. H₂O, ATM.
Q/AΘ = BTU/SQ.FT./HR.
CORRECTION DUE TO USE OF FIGURES AND OR AND , WHEN GAS CONTAINS BOTH CO₂ AND H₂O.
T, °F
a
b

Figure 3

THICK GAS LAYER CORRECTION FACTOR CHART

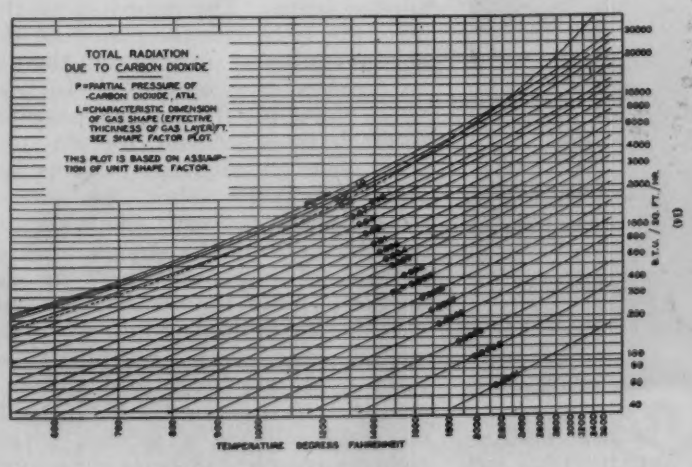

TOTAL RADIATION DUE TO CARBON DIOXIDE
P=PARTIAL PRESSURE OF CARBON DIOXIDE, ATM.
L=CHARACTERISTIC DIMENSION OF GAS SHAPE (EFFECTIVE THICKNESS OF GAS LAYER) FT. SEE SHAPE FACTOR PLOT.
THIS PLOT IS BASED ON ASSUMPTION OF UNIT SHAPE FACTOR.
TEMPERATURE DEGREES FAHRENHEIT

FIGURE 1

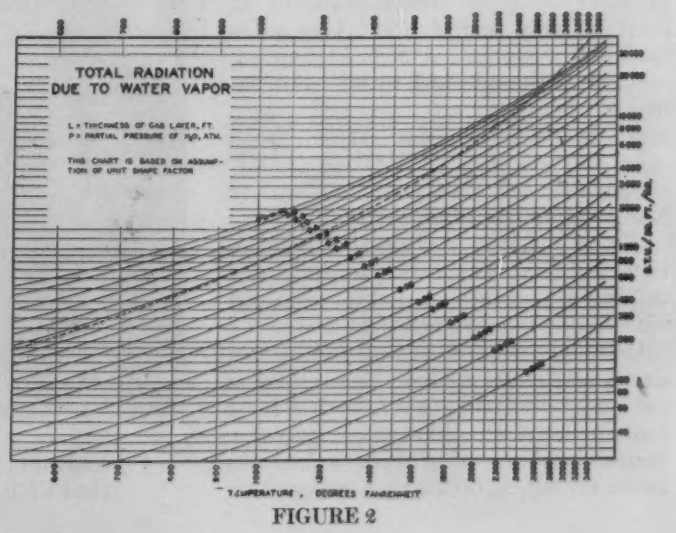

TOTAL RADIATION DUE TO WATER VAPOR
L = THICKNESS OF GAS LAYER, FT.
P = PARTIAL PRESSURE OF H₂O, ATM.
THIS CHART IS BASED ON ASSUMPTION OF UNIT SHAPE FACTOR
TEMPERATURE, DEGREES FAHRENHEIT

FIGURE 2

*A. Schack, Mitt. 55 der Warmestelle Dusseldorf der Vereines deut. Eisenhl (1924).

†A. Schack, Zeit. fur Tech. Physik, *5* (1924), 266.

Television

A description of the apparatus and methods used in the simultaneous transmission of sound and light

By PHILIP CHAPIN JONES, '12
Bell Telephone Laboratories

ON the afternoon of April 7, 1927, Mr. Hoover, Secretary of Commerce, sat in a room in Washington before a rectangular cabinet a little over two feet wide and about as high. It was a non-committal sort of thing with an opening through the middle of it from front to back approximately ten inches square. At each side and above this central opening, recessed into the main cabinet, were long glass tubes with helical windings running down their centers. Directly back of this cabinet were two more, one behind the other. None of them gave any indication of what they might contain but Mr. Hoover had been told that these silent and mysterious cases had within them some hidden power which would transmit his image as it moved and spoke into the telephone conveniently at hand, to the auditorium of Bell Telephone Laboratories in New York City, over two hundred miles away. He knew he was sitting before the television transmitter.

In the course of the last hundred years many startling inventions and discoveries have been made. The locomotive, the telegraph, the telephone, electric light and motors, the phonograph, the automobile and aeroplane, the moving picture, and many others have revolutionized our mode of living and almost our manner of thought. Each has had its element of novelty and originality and over each has hung a halo of miraculousness. None of them, however, has been more startling or more inexplicable to the man in the street than has television.

Knowing the expansive force of steam it is not difficult to comprehend the possibility of a steam engine. Similarly a familiarity with the pull of an electromagnet makes a motor at least vaguely conceivable. The automobile, the aeroplane, or the telegraph and the motion picture, titanic achievements as they are, do not baffle ordinary comprehension. When, however, one sees a demonstration of television he feels the props of reality being pulled from beneath him.

There is no understandable connection between a person smiling and talking in a room in a distant city and his life-like image smiling at us from a little square window in a cabinet before us. A telephone with all its mystery is yet understandable to one with a little familiarity with elementary physics. Sound is a train of pressure variations in the air which, falling on a transmitter diaphragm, vibrate it back and forth. The way in which this varies the pressure of a small mass of granulated carbon and thereby causes a varying current to flow which closely duplicates the sound waves, can be readily understood in principle. The reconversion to sound at the other end of the line by allowing the varying current to exert a correspondingly varying pull on the receiver diaphragm, thereby causing like vibrations in the air, can also be comprehended. Television, however, is apparently a thing of an entirely different genera.

A magician never explains his wonders, for once their mechanism is understood, immediately their mystery and appeal is gone. The scientific worker, on the other hand, does not seek praise and reward based on the ignorance of the audience. The more completely his work is understood the more he feels his mission is being fulfilled. The purpose of science is to clarify, so that having produced and exhibited this modern miracle, television, science's next step is to explain it. The greater the extent to which its mystery is clarified the nearer will science have attained its objective.

The problem of television is divided, as is any electrical communication problem, into three parts: a conversion of the thing to be transmitted to an electric current, the transmission of that current without harmful distortion, and the reconversion of the electric current at the receiving end to a sufficiently accurate replica of the original thing.

THE RECEIVING END OF THE TELEVISION APPARATUS

The conversion of sound to electricity, as has already been remarked, is comparatively simple because it involves the conversion of air pressure varying with time to an electric current varying with time. The image of an object, however, is not a temporal succession of anything but a spacial arrangement or mass of light intensities so that for television the first and last steps are divided into two: at the sending end, the conversion of a spacial arrangement to a temporal one and then the conversion of this to a varying electric current, and at the receiving end a similar but reversed process.

Probably the principal difficulty of television lies in this additional function: the mutual conversion of spacial arrangements and temporal sequences. The method adopted divides the scene to be sent into a large number of small areas which are transmitted successively and at the receiving end replaced in their proper space arrangement. The actual dividing up of the scene and its rearrangement at the other end is done mechanically but there is required in addition a time integration at the receiving end. This integration is accomplished by a peculiar trait of the eye known as "persistence of vision."

An object flashed before us remains as a visual sensation for an appreciable time after the actual object has disappeared. It is this phenomenon that makes a sequence of pictures representing the successive positions of a moving object, flashed before our eyes at the rate of about eighteen per second, appear as a continuous but moving scene. The sensation of the first view lasts over the period till the next one takes its place so that there is no break in the continuity. In television the application of this principle is much more difficult, for not only must there be eighteen pictures per second so as to obtain the moving picture effect but each single picture must be made up of a large number of successive component views of elemental parts of the scene being sent.

The scene is divided into 2,500 elemental areas which are transmitted successively at the rate of 45,000 a second, thus covering the field once in an eighteenth of a second, giving eighteen complete pictures per second.

Each of the elemental areas are converted successively to electric currents proportional to their light intensities, transmitted one after the other, and reconverted at the receiving end to a similar arrangement of small areas of the proper brightness and with the same arrangement. The fineness of detail which can be transmitted is a function of the number of these elemental areas. The more elemental areas the scene is divided into the finer will be the grain of the picture but it was decided that the number chosen was sufficiently great to give satisfactory results.

As a means of converting light to electricity, the photoelectric cell proved the most suitable. A special tube over fourteen inches long was developed which is probably larger than any that had been used before. The inner surface of the rear half is coated with an alkaline metal such as sodium which serves as the cathode. The anode is a coil of wire of inactive metal such as platinum or nickel wound over a glass rod running down the center of the tube. When the tube is connected into an electric circuit containing a source of electromotive force, a current flows which is directly proportional to the amount of light falling on the metallic inner coating of the cell. The action of the cell is practically instantaneous and follows very closely a straight line relationship.

As a method of breaking up the field of view into the 2,500 successive elementary areas a scanning disk is used. This is a steel disk fifteen inches in diameter with a spiral of fifty small holes, less than three hundredths of an inch in diameter, drilled through it near its outer edge. Between it and the transmitted scene is a stationary steel plate, with a rectangular opening cut in it opposite the outer edge of the disk. The opening is of such a size, about an inch square, that there is never more than one hole of the disk opposite it at a time. As the disk revolves one hole is just passing below the lower edge of the opening as the next hole is appearing at the upper edge. Due to the spiraling, each hole traces a line across the disk just to one side of the preceding one. A very slight overlapping is allowed. As the innermost hole of the spiral completes its line along the inner edge of the opening the first hole is just ready to start a new cycle at the outer edge.

TRANSMITTING APPARATUS

Through the large opening comes the pencil of light that swiftly moves over the face of the operator. On top of the opening is the photoelectric cell which changes the light and dark reflections of the pencil of light to different electrical intensities.

Behind the disk is an arc light which by suitable lenses, is focused on the rectangular opening of the plate. The disk intervenes, however, allowing at one time only the light that passes through one of its holes to continue through the rectangular opening. So small are these holes that the light is not noticed by the person whose image is being sent.

The plate opening is opposite and back of the ten-inch square opening through the cabinet, containing the photoelectric cells. The disk is maintained at a constant speed of eighteen revolutions per second by a synchronous motor.

In its skeleton form this is the television transmitter; a powerful source of light so located and controlled that its rays would flood the transmitted scene through the rectangular opening in the plate were it not for the intervention of the rotating scanning disk. The spiral of holes in this disk, throws successive small spots of light on the scene, which travel across it in a nine-hundredth of a second. The light reflected from the small illuminated dots falls on the photoelectric cells causing small momentary currents to flow. The amount of light reflected, and hence the strength of the resulting current, is proportional to the brightness of the scene at that spot. As there is always one spot of the scene illuminated there is always light falling on the cells so the current actually transmitted is not a series of impulses but a continuous flow of varying intensity.

The receiving apparatus is similar but of converse function. The arc light is replaced by a neon tube which glows with a brightness proportional to the strength of the received current. A stationary plate with a rectangular opening and a scanning disk, similar to, but twice as large, as that of the sending apparatus, permits the tube to be seen through one hole at a time. The watcher looks at a rectangular opening which is about two by two and a half inches on a side. Behind this is the scanning disk whose holes successively race across the rectangular opening revealing at each position the brightness of the neon tube at that instant. Due to the "persistence of vision" the eye sees not a succession of bright points, but the whole rectangular field lighted at the same time but with different intensities at different points. As the scanning disks at the two ends of the circuit are accurately synchronized the brightness at any position of the receiving disk corresponds to the brightness of the scene at the sending end at the corre-

(*Continued on page 358*)

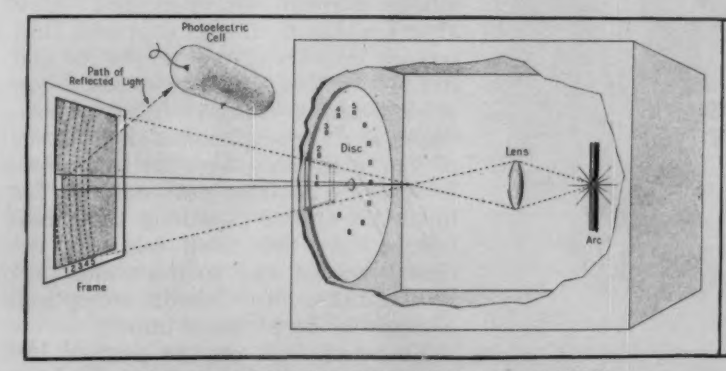
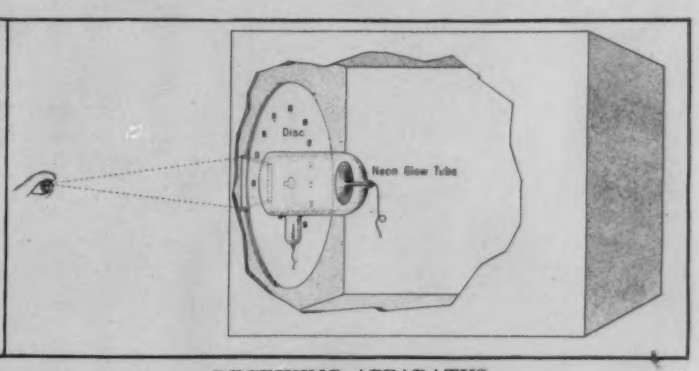


DIAGRAM OF TRANSMITTING APPARATUS

Light from the arc passes through openings in the revolving disk. The reflection of the light on the frame is received by the photoelectric cell.



RECEIVING APPARATUS

The Neon glow tube has the unique quality of changing its intensity almost instantly to correspond with different impressed terminal voltages.

Industrial Plant Dust Explosions

The development of methods for their control and prevention

By DAVID J. PRICE

Engineer-in-Charge, Chemical Engineering Division, Chemical and Technological Research, Bureau of Chemistry and Soils, U. S. Department of Agriculture, Washington, D. C.

IN recent years considerable attention has been given to the determination of the causes of dust explosions in industrial plants and the development of methods for their control and prevention. Although the United States has practically had the leadership in the undertaking,* extensive investigations have been carried on in European countries also.†

The explosion in the Washburn Flour Mills in Minneapolis, Minnesota, on May 2, 1878, in which eighteen lives were lost and a number of separate mill buildings were destroyed, is usually referred to as the first industrial plant dust explosion in the United States. An explosion of "middlings dust" is reported to have occurred, however, in an Illinois flour mill in 1864. Records of several similar explosions between 1864 and 1878 are available.

The *American Miller*, a nationally recognized trade journal of the flour milling industry, in January, 1889, refers to an explosion of flour dust, reported in the Memoirs of the Academy of Science of Turin, Italy, which occurred in a flour warehouse on December 14, 1785. The account in the Memoirs, given by Count Morozzo, was translated and printed in Volume No. 2 of the "Reportory" in 1795. The report stated that the flour dust was ignited by an open flame lamp. Investigation of this explosion resulted in securing evidence that a similar explosion in Italy occurred as early as 1755.

It will not be practical in this article to give a historical résumé of dust explosion studies. It is desired to deal with certain aspects of this work that may be of interest to engineers who will be called upon to deal with the dust explosion problem in the industries and to develop further control methods. It is of sufficient importance, however, to state that although the early dust explosions, both in the United States and abroad, occurred in flour mills and flour warehouses, largely on account of the pioneer nature of this industry, marked progress has been made in both control and prevention. The explosion in Minneapolis in 1878 resulted in the development of efficient mechanical methods of dust collection, and the flour milling industry has taken advantage of every opportunity to eliminate the dust explosion hazard. This protection has been so thorough that the present large losses from dust explosions are occurring in what might be considered "new lines" of industry involving new manufacturing processes and production methods.

*Dust Explosions, Price and Brown, National Fire Protection Association, Boston, Mass. (1922).

†Staub-explosionen, Beyersdorfer, 1925, Theodor Steinkopff, Leipzig. The Dust Hazard in Industry, Gibbs, 1925, Ernst Benn, Ltd., London.

RESULT OF DUST EXPLOSION

This modern reinforced concrete grain elevator had a capacity of 10,000,000 bushels. The explosion killed six men and destroyed about $4,000,000 worth of property

Interest First Aroused in 1888

It is always of interest to observe the public mind when any new conclusion is reached in establishing the cause of these "mysterious industrial explosions." This is particularly true in the unusual interest manifested as the result of an explosion in an oatmeal mill in Chicago on December 11, 1888. The report states that this explosion was heard several miles away, and "hundreds of people were awakened, many of them thrown from their beds."

This explosion provoked considerable discussion in the popular press, all centering on the possibility of an "oatmeal" explosion. One of the prominent Middle West papers seemed much concerned over the fact that "this is the first time it has been suggested that oatmeal has volcanic properties, its worst characteristic, in the popular mind, being its disposition to irritate the skin and set a man to rubbing his back against the door jamb."

This paper saw some relief, however, in this new theory, intimating that if it was found that "oatmeal" was explosive, then a good many mysterious disappearances might be accounted for. It referred to the disappearance of an Ohio town treasurer as follows: "He was last seen on his way to the village through an open field, soon after breakfast. It was supposed that he took the cars at another station and has fled to Canada. The words, 'soon after breakfast' may be full of significance, and the suspicion of the honesty of the man may be cruelly unjust. Everybody in Ohio eats oatmeal for breakfast and it is among the possibilities that this town treasurer exploded on his way to town and that he did not go to Canada, excepting, perhaps, a few pieces of him."

This comment on the part of the popular press was general throughout the country, and the possibility of a "breakfast food" exploding was responsible for many humorous news-

paper accounts. The following is typical: "Until the question is definitely settled whether oatmeal is explosive, people should be a little cautious about riding down town in a morning street car with any Scotch fellow citizen. No man can tell how many bombs are walking about the streets filled with the dynamic force of an oatmeal breakfast. While we are feeling gay in fancied security, we may at any moment be blown higher than Gilderoy's kite by a bowl of oatmeal mush."

One of the southern papers saw alarm in the situation and commented as follows: "The explosion of that oatmeal mill in Chicago on Tuesday will probably cause a decline in the use of that hygienic article of food. No man is going to risk an explosion in his abdominal regions simply because a doctor tells him his oatmeal is healthy."

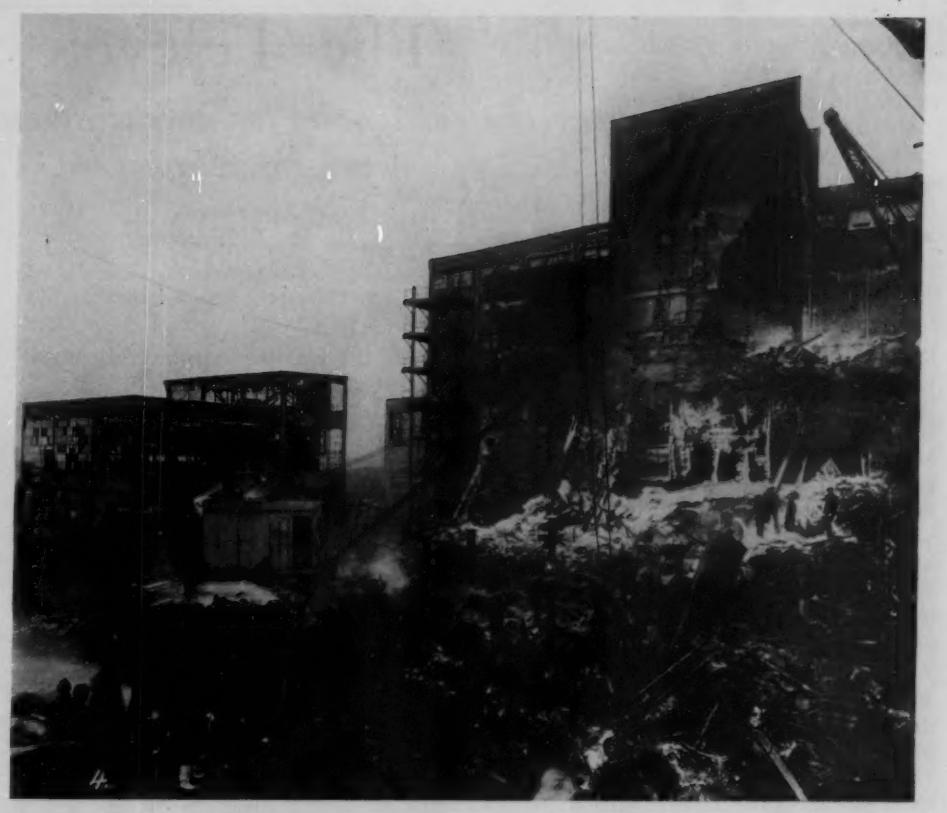
Extent of Industries Affected

The Chemical Engineering Division of the Bureau of Chemistry and Soils of the United States Department of Agriculture, is conducting special research investigations to determine the causes of industrial plant dust explosions and resulting fires, and the circumstances under which they can originate. As a result of the investigation of a large number of explosions, it is concluded that under favorable conditions a dust explosion can occur in any industrial plant or manufacturing establishment where combustible dust is created during the operating processes. Approximately 28,000 industrial plants in the United States are subject to the dust explosion hazard and should adopt precautionary measures. These plants employ approximately 1,324,422 persons and annually manufacture products valued at more than $10,000,000,000.

The Bureau has record of 300 dust explosions in industrial plants. In 77 of these explosions 496 persons were killed, and in 105 explosions 875 were injured. In 161 cases the property loss amounted to $39,706,108, an average of nearly $247,000 for each explosion.

Similarity to Gas Explosions

A dust explosion is somewhat similar to a gas explosion. The dusts require definite ignition temperatures, and also have what might be termed the lower and upper limits of concentration. The lower limit of methane gas, CH_4, is 5.5 per cent, and the upper limit is approximately 14.5 per cent. The lower limit of concentration for hydrogen gas and air has been given as 4.1 per cent. The upper limit is as high as 72.4 per cent. The lower limit of carbon monoxide gas, CO, is approximately 12 per cent. The upper limit is about 72 per cent. Cornstarch dust can ignite at a concentration of approximately 0.007 ounces per cubic foot, or 7 ounces per thousand cubic feet. It is quite likely that the explosive dusts also have upper limits of concentration.



AFTER AN EXPLOSION OF STARCH DUST

The building on the left was saved from destruction by the large window glass area. The packing house was completely destroyed and forty-two men lost their lives

Occurrence of Dust Explosions

Dust explosions in industrial plants occur in various ways. Most of these explosions naturally happen during the normal operating process, but others have happened under unusual conditions. Some have occurred after the plant was shut down. Three destructive explosions in grain elevators originated when the elevators were not in operation. In one, the cause of the explosion was an unnoticed smoldering fire started just before the plant was shut down; in another dust was stirred up while the grain driers were being cleaned. In the third disastrous grain elevator explosion, the plant was closed down and workmen were cleaning the basement.

Effects of Dust Explosions

The rupturing of heavy construction and the carrying of heavy blocks of concrete some distance from plants show that immense pressures are developed in some of these explosions. As the result of an explosion in a grain elevator in the Southwest, a piece of concrete weighing over 1,500 pounds was found more than 300 feet from the elevator. Reinforced concrete pillars, 16 inches by 24 inches in cross section, were blown down, and 1½-inch steel reinforcement rods were completely stripped of concrete. These columns weighed approximately six tons each and with their reinforcements should have withstood enormous pressures. Conveyor tunnels covered with 16 inches of concrete were blown apart, and heavy blocks were carried considerable distance.

Perhaps the most destructive force known to have been developed in an explosion of industrial plant dust was generated in an explosion in the world's largest grain elevator, in the Middle West. In one corner of the grain storage section, 40 bins were moved on their foundations nearly one-half foot. These bins were approximately 95 feet deep, averaging 20 feet in diameter, and were built of 7-inch reinforced concrete. Cracks between these and the adjoining bins and their foundation piers showed that they had been lifted. The bins and the grain they contained would probably weigh more than 300,000 tons. As a result of the explosion about 20 of these bins were completely shattered. This gives some indication of the tremendous force of the explosion which occurred in the tunnels underneath these bins.

Some Interesting Observations

It has been observed that explosions in industrial plants vary in intensity

(*Continued on page 362*)

The Televox

A supervisory control scheme for operating substation equipment over the telephone

By R. J. WENSLEY
Switchboard Engineer, Westinghouse Electric and Manufacturing Company

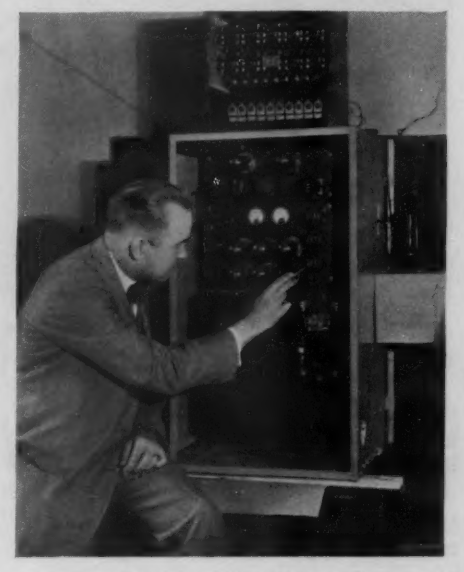
THE big problem that has always confronted electric utility companies is that of furnishing the best possible service with the least possible cost. With the development of extensive power systems came many new distribution problems. One of the best distribution systems from the standpoint of service is that of running high tension lines to numerous small substations located at strategic points where the power is most needed, and running short low tension feeders from the substations to customers. From an economical standpoint, however, this system has some disadvantages. The operating expenses increase as the number of substations increase because more operators are required to operate the additional substations.

The introduction of automatic control for substations brought about an appreciable reduction in the labor item of operating expense. This system of control proved very successful, but it had some limitations that the manually operated stations did not have. One of the disadvantages of automatic control is that the operator at the central station has no way of knowing whether or not the distant substations are functioning properly.

In an effort to gain a more centralized and more flexible control, many utility companies have installed a supervisory control system. This system has several advantages over the automatic system of control, but it has the disadvantage of being more expensive.

With supervisory control, the more elaborate stations require two pairs of wires, which must be continous from the dispatching point to each substation. The cost of renting wires in telephone cables or of erecting private lines prohibit the use of supervisory control for smaller or relatively unimportant stations.

During the last few years much pioneer engineering has been carried on in an attempt to find a simple and more satisfactory means of communicating with unattended stations. Carrier currents have been used with a fair degree of success, but this system was not practicable because of the high cost involved.



MR. WENSLEY AND THE TELEVOX

Mr. Wensley prepared this article exclusively for THE TECH ENGINEERING NEWS. It is one of the first articles to be published free from the sensationalism which has characterized the appearance of the Televox in the daily press. We take great pleasure in presenting this article to our readers for this reason.

The Bell Telephone has long been a reliable communication system and provides an ideal means of transmitting oral instructions to a manually operated station. With this thought in mind efforts were made to find ways to use the existing telephone lines for controlling unattended substations. The telephone companies, justly proud of their service, prohibit any attachments to the instruments or circuits of the subscribers' installation. Accordingly, any automatic operator capable of using the telephone must be able to receive commands and transmit replies by some audible means. Out of this requirement grew the Televox.

It was first necessary to develop a vocabulary that the Televox could speak and understand. In order to keep the language of the Televox as simple as possible the first models were limited to three distinct monotones, which are produced by tuning fork oscillators having periodicities of 600,900, and 1400 cycles. These frequencies are all within the range of frequencies that can be transmitted over the telephone with good efficiency. Higher frequencies which are even multiples of the two lower frequencies were avoided. It will be noted that the upper frequency of 1400 cycles lies between the second harmonics of the lower tuning forks which are 1200 and 1800 cycles respectively.

The Televox unit, which is placed on the dispatcher's desk near the phone, contains three tuning fork oscillators, a two stage audio amplifier, and a loud speaker or howler. Each tuning fork is connected mechanically to a transmitter button. This transmitter button varies the battery current, causing a pulsating current of a frequency equal to the frequency of the tuning fork in the primary of a transformer. The secondary of this transformer is

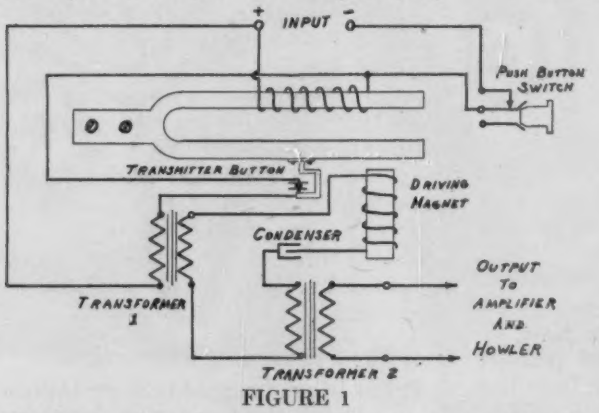


FIGURE 1

The diagram shows how an alternating current equal to the natural frequency of the tuning fork is produced

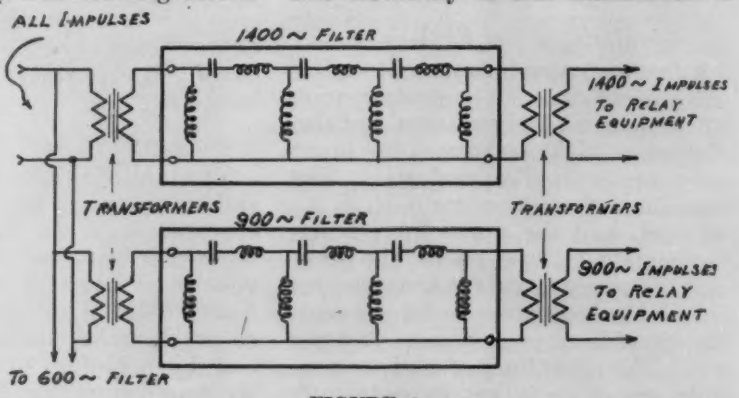


FIGURE 2

A diagram of the circuits that assign the different sound impulses to their particular duties in the power substation

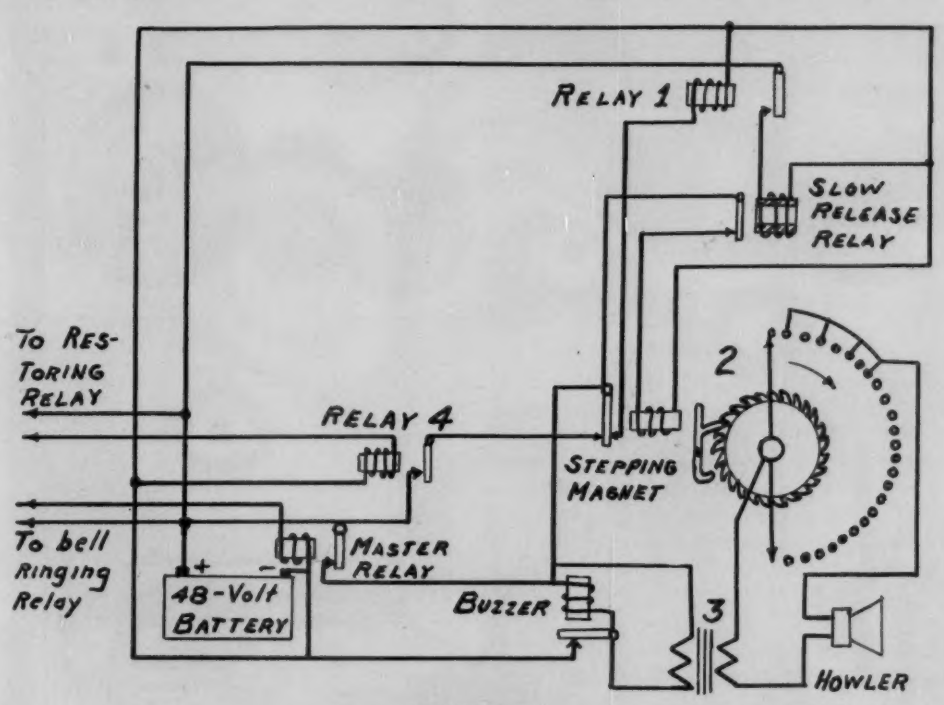


FIGURE 3

This portion of the Televox equipment answers the telephone at the substation and informs the dispatcher at the central station that he has the right number

connected in series with the electro magnet that drives the fork and the primary of the amplifier that feeds the howler circuit. (See figure 1.)

When the push button switch is closed some current passes through the transmitter button and the primary of transformer 1. As this current builds up it induces a current in the driving magnet circuit sufficient to attract the tuning fork. This motion of the tuning fork reduces the pressure on the transmitter button, increases the resistance, and decreases the current. As the current in the primary of transformer 1 decreases it induces a current in the driving magnet circuit. The second induced current in the driving magnet circuit is in an opposite direction to the first induced current and causes the magnet to repel the tuning fork. As the tuning fork returns to its original position, it increases the pressure upon the transmitter button, reduces the resistance, and allows the current in the primary of transformer 1 to build up again. The fork vibrates in this manner at a rate equal to its natural frequency and produces an alternating current of the same frequency in the primary of transformer 2. The current from the secondary of transformer 2 is amplified and used to produce in the howler a high pitch tone of a frequency equal to that of the tuning fork. A selective dial and three keys are arranged to permit the dispatcher to impress any of the three frequencies upon the howler circuit.

The Televox unit at the distant substation is more elaborate, however, because it must be capable of receiving commands over the telephone, performing switching operations, and making replies. This unit has three major parts: a receiving set, a system of control circuits, and a transmitting set. All parts are interconnected and are contained in one cabinet.

The receiving set has two distinct functions. It raises the telephone receiver and transmits all signals from the receiver to the control circuits of the Televox. During the demonstrations of the first Televox the telephone receiver was removed from the hook and placed on a microphone which was the ear of the Televox. A weighted arm was used to hold the hook switch of the telephone down. The apparatus used to lift the weight arm when the station is called consists of a bell ringing relay furnished by the telephone company, a master relay, a time delay relay, and weight-lifting magnet. Each filter circuit is connected to a control relay through a transformer and rectifier. The 1400 cycle filter has a sharp resonant point of 1400 cycles and offers a very high impedance to all currents of higher or lower frequencies. The 900 cycle filter offers a high impedance to all currents except those having a frequency within the limits of 895 to 905. In this way the 600, 900 and 1400 cycle currents are assorted and passed on to their respective control circuits.

The secondaries of the transformers are connected to three filter circuits that are tuned to frequencies of 600, 900, and 1400 cycles as shown in figure 2. This diagram shows two of the three filter circuits of the Televox. All signals received by the "ear" pass through a two-stage audio amplifier to the primaries of three transformers connected in parallel.

The transmitter set of the Televox has a buzzer connected to the primary of a transformer, the secondary of which operates a howler. The howler circuit is controlled by a group of selective switches operated by a stepping magnet. (See figure 3.)

This wiring diagram shows part of the Televox equipment in substation number four and illustrates the opera-

(Continued on page 354)

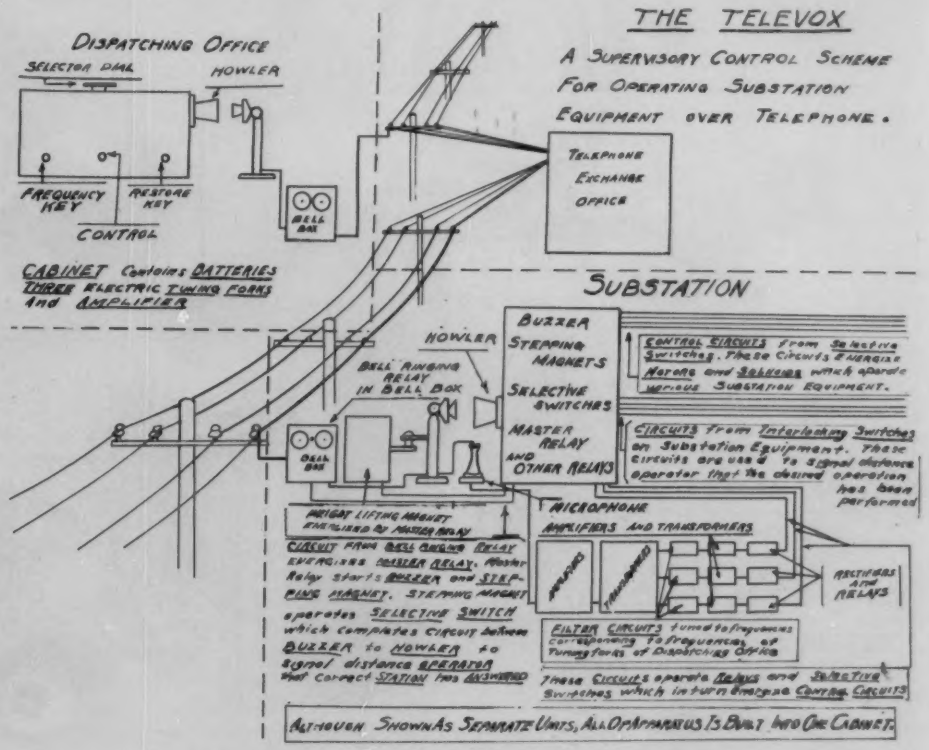

THE TELEVOX
A SUPERVISORY CONTROL SCHEME FOR OPERATING SUBSTATION EQUIPMENT OVER TELEPHONE.
DISPATCHING OFFICE
SELECTOR DIAL
HOWLER
FREQUENCY KEY
RESTORE KEY
CONTROL
BELL BOX
TELEPHONE EXCHANGE OFFICE
CABINET Contains BATTERIES THREE ELECTRIC TUNING FORKS And AMPLIFIER
SUBSTATION
HOWLER
BELL RINGING RELAY IN BELL BOX
BUZZER
STEPPING MAGNETS
SELECTIVE SWITCHES
MASTER RELAY AND OTHER RELAYS
CONTROL CIRCUITS from Selective Switches. These Circuits Energize Horns and Sirens which operate various Substation Equipment.
CIRCUITS from Interlocking Switches on Substation Equipment. These circuits are used to signal distance operator that the desired operation has been performed
WEIGHT LIFTING MAGNET ENERGIZED BY MASTER RELAY
MICROPHONE
AMPLIFIERS AND TRANSFORMERS
RECTIFIERS AND RELAYS
CIRCUIT FROM BELL RINGING RELAY ENERGIZES POWER RELAY. Master Relay Starts BUZZER and STEPPING MAGNET. STEPPING MAGNET operates SELECTING SWITCH which completes circuit between BUZZER to HOWLER to signal distance OPERATOR that Correct STATION has ANSWERED
FILTER CIRCUITS tuned to frequencies Corresponding to frequencies of Tuning forks of Dispatching Office
These Circuits operate Relays and Selective Switches which in turn Energize Control Circuits
ALTHOUGH SHOWN AS SEPARATE UNITS, ALL OF APPARATUS IS BUILT INTO ONE CABINET.

FIGURE 4

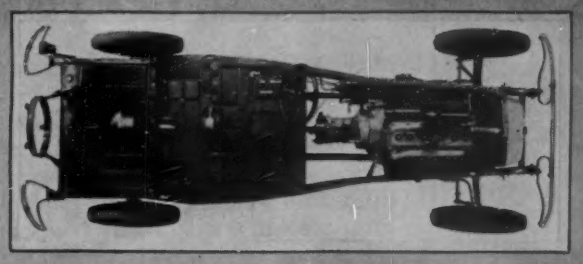


FIG. 1
Plan View of Dodge Victory Six Chassis showing New Type of Combined Frame and Body construction.

FIG. 2
Steeldraulic Brakes Used on Dodge Four.

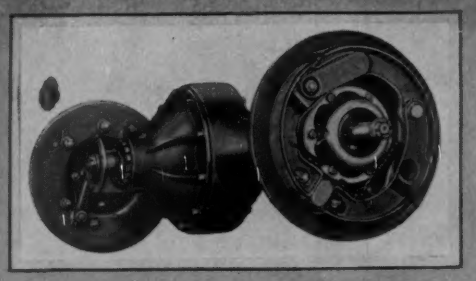


FIG. 3
Rear Axle and Brake of Marmon 68.

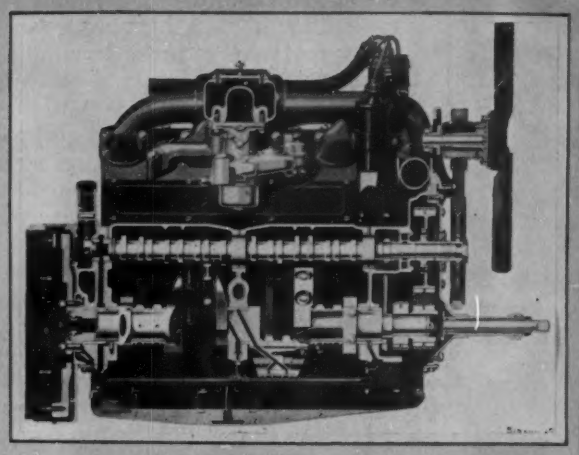
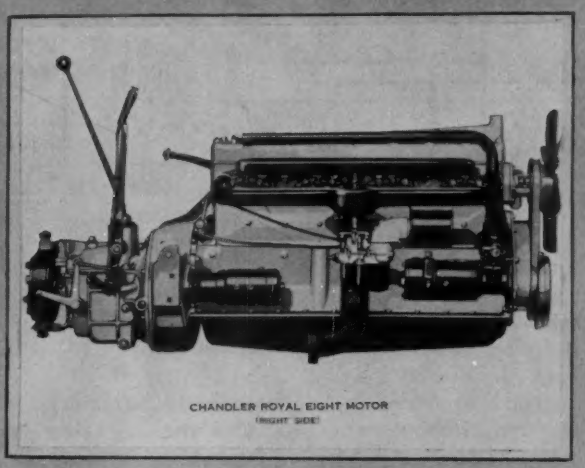


FIG. 4
Left: Cross section of 341 Cadillac showing Connecting Rods and Drilled Crank Shaft.

FIG. 5
Right: Right Side of Chandler Eight showing Manifolding.



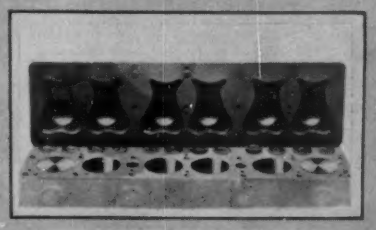


FIG. 6
G. M. R. head for L head engine as used on Oakland and Pontiac.

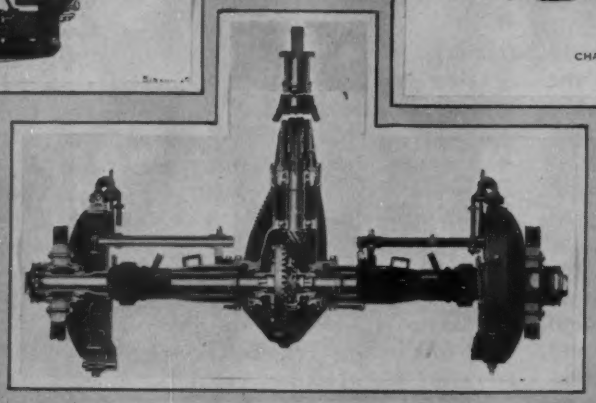


FIG. 7
Cadillac full floating Axle with Torque Tube Rod.

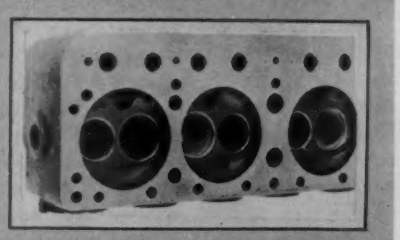


FIG. 8
G. M. R. Head as Adapted to Valve in Head Engine on Buick.

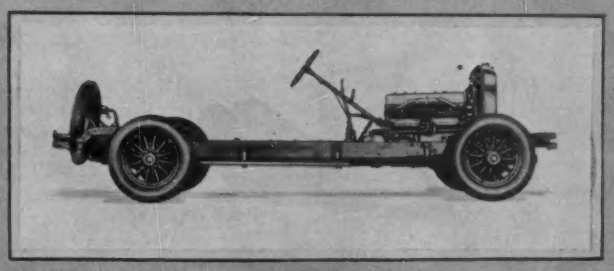


FIG. 9
Elevation of Marmon 78 Chassis.

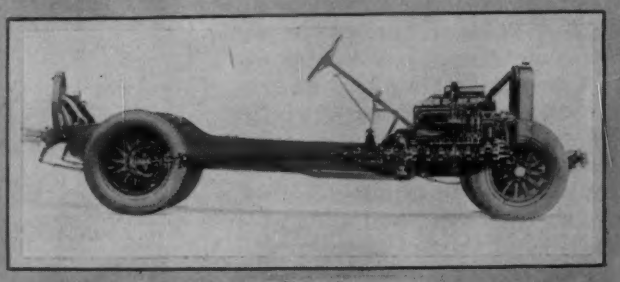
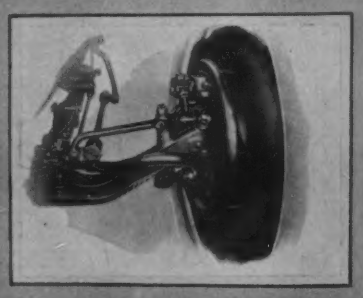


FIG. 10
Elevation of Dodge Six Chassis.

FIG. 11
View of New Chevrolet Mechanical Front Wheel internal expanding brake and shock absorbing spring with counter leaves. These brakes are simple in construction and will not lock outside wheel on turn.



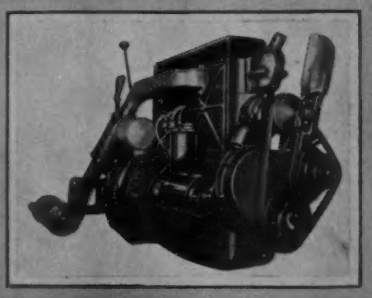


FIG. 12
Right side of 1928 Chevrolet showing completely enclosed engine, two port exhaust manifold cleaner, AC air cleaner, oil filter and Delco Remy ignition. A thermostat is mounted in water outlet from the block.

Automotive Developments for 1928

An illustrated discussion of the principal changes in the 1928 automobiles

By Adam K. Stricker, Jr., '29

THE past year has witnessed a great many developments in the automotive industry of a technical nature and the new year has already opened with announcements of new models by Ford, Chevrolet, Dodge, Essex, Pontiac, Studebaker, Hupmobile and Marmon. The past year in the low-priced field centered on the announcement of the Ford Model A, which incorporates a great many improvements. The bore and stroke has been changed to 3⅞" x 4¼", giving a displacement of 205 cubic inches. Aluminum pistons have been fitted which have contributed to a greatly improved performance. The lubrication system has been improved by the addition of a pump which delivers the oil to the chamber containing the valve mechanism from which it flows by gravity to the engine bearings. A pump driven by the fan belt has been added to the cooling system, which gives better cooling at high loads and speeds. One of the most radical changes has been the elimination of the familiar flywheel magneto and individual coil ignition for each cylinder by a modern design of distributor and interrupter mounted on the cylinder head. This unit is driven by a shaft geared to the camshaft which carries the oil pump at its lower end. The carburetor is a one-inch Ford Zenith which gives excellent acceleration and economy. A fabric camshaft gear with helical teeth has been incorporated in the timing drive to give quieter operation to the front end. The car has a wheelbase of 103½ inches with a thread of 56 inches. Four-wheel brakes of an original design have been fitted, to give better deceleration. The total braking area is 168 square inches. The familiar planetary transmission has been replaced by a conventional three-speed and reverse selective sliding gear transmission with standard shift. The main shaft is mounted on ball bearings, the jackshaft on roller bearings, while the reverse idler is mounted on a plain bearing.

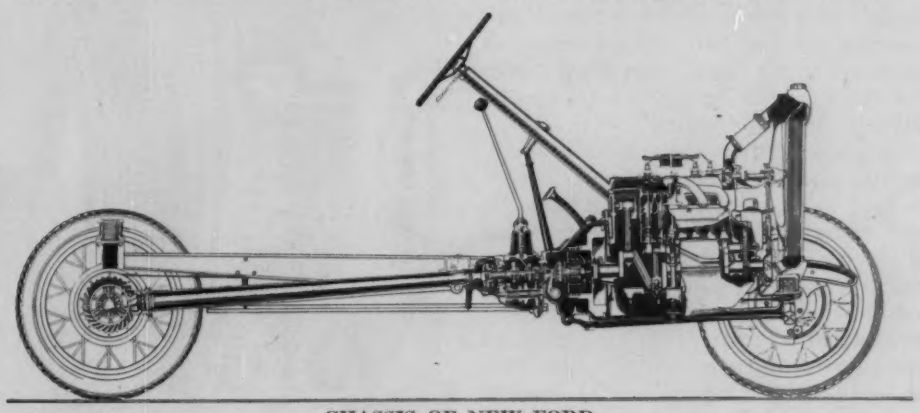
The general design and construction are of a high quality employing heat-treated chromium steel gears. A multiple disk clutch with four driving and five driven disks is used in conjunction with this transmission.

The rear axle is now of the three-quarter floating type and is built by welding steel forgings to steel tubing to form the axle housing. These are bolted to the differential housing, which is made from rolled channel steel.

The strong suspension is still of the transverse semi-elliptic type supplemented by hydraulic shock absorbers. The planetary steering gear has been abandoned in favor of an irreversible worm and sector gear.

The whole car is a tremendous improvement over its predecessor, but it embodies no new scientific principles. One of the most interesting features is the great number of forgings used which is not usual in a car of this type.

The General Motors Corporation has just announced a 1928 model Chevrolet which embodies many basic improvements. This car is designed to cover the market for a high quality low-priced car. One of the principal changes has been a four-inch increase in wheelbase, giving the car a wheelbase of 107 inches.



CHASSIS OF NEW FORD

The engine has been redesigned to give 35 horsepower as compared to 26 at 2200 rpm with no change in cylinder dimensions. This improvement has been brought about by increasing the valve diameter from 1½" to 1 21/32", the valve lift from 5/32" to 9/32", and the inlet manifold diameter is now 1/8 inch larger, while larger carburetor jets have also been employed The compression ratio has been raised from 4.33 to 4.50, with a resulting gain in operating efficiency.

Aluminum alloy pistons with invar struts are used to reduce the weight of the reciprocating parts, improving performance and engine balance without incurring the usual troubles of seizing or piston shap.

The engine is a great deal quieter, as the push rods are now completely enclosed and the cam followers have been redesigned with this end in view. A fabric camshaft gear has also contributed to a quieter engine.

The cooling system has been redesigned and the capacity has been increased by one quart to take care of the increased power. The aluminum pistons dissipate heat more rapidly, which has placed a further load on the cooling system. A pressed steel radiator shroud has been fastened to the inside of the radiator, and a thermostat has been placed in the water outlet from the cylinders. The engine is equipped with Delco Remy electrical equipment, A. C. air cleaner and oil filter, and vacuum fuel feed. Crankcase ventilation has been installed as on the other General Motors Cars, lengthening the life of the lubricant considerably. Figure 12 is an illustration of the right side of the engine, showing the above features.

Four wheel brakes of a unique design have been installed. The front brakes are mechanically operated and are of the internal expanding two shoe type. The pressed steel shoes are pivoted at the bottom and are operated at the top by a cam bearing on rollers at the ends of the shoe. The rear service brakes are external contracting, and are operated in conjunction with the front brakes through a cleverly-designed brake effort proportioner.

The emergency brakes are entirely separate from the service brakes, and consist of internal expanding brakes on the rear wheels. Figure 11 show the operating mechanism for the front brake. The axle is of the reversed Elliot type, and the ends have been redesigned to take the torsional loads of front wheel braking. The steering knuckles are mounted on ball thrust bearings. A new type of spring is employed in which short leaves with reverse camber are fastened to the

main spring to take up the rebound and dampen oscillations by increasing the interleaf friction. It is surprising what an effect this simple device has on the riding qualities of the car.

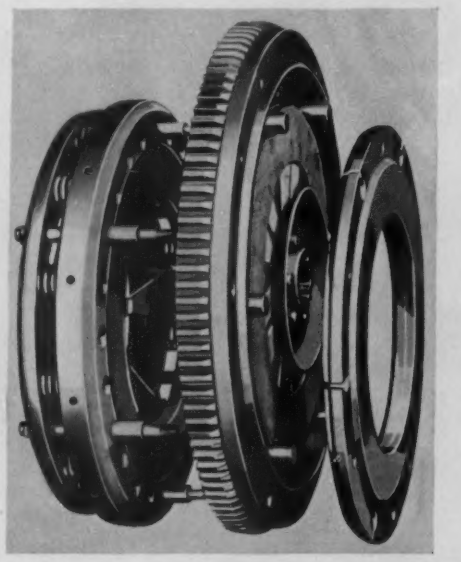
The Dodge Company have installed steeldraulic brakes on their four cylinder cars, which should give excellent braking with very little need of adjustment. The inside of the drum is shown in Figure 2. This Company has also announced a new model to be known as the Victory Six which is noteworthy because of its combined frame and body. Figure 1 is a plan view of the chassis, and the reader can readily observe how the floor of the body has been built into the frame, giving a very stiff structure. The body is built without the usual sills, and welding is used throughout the construction. A low overall height is secured without any sacrifice of head room.

The engine is very well designed, and it has shown exceptional performance. Figure 13 is a view of the Dodge engine; Figure 10 is a sectional view of the chassis of this car.

The Essex have announced a new model with front wheel internal expanding mechanical brakes. Several minor changes have been made, but the front wheel brakes are the only outstanding development.

General Motors has made a great many changes on the Pontiac designed to give more satisfactory performance and operation. The most interesting of these is the Harrison cross flow radiator. The flow of the cooling medium is from a tank at the left to another at the right of the core as opposed to the conventional practice of verticle flow from a tank at the top to one at the bottom. Losses of water and anti-freeze are decreased with this type of construction, and the dangers of freezing are minimized.

A new type of cylinder head has been developed by the General Motors Research Laboratories which reduces the tendency for detonation, permitting higher compression and greater power. This head has been fitted to other General Motors products for some time, and it is now standard on the Pontiac. Figure 6 shows the shape of this head. Figure 8 shows the cylinder head used on the Buick, which is an adaptation of these principles to the valve-in-head engine. These heads are representative of the new era in automotive design in which research is the dominating spirit of all changes. Designers are no longer working in the dark, using empericism as their guide, but are now turning to the research worker to ascertain the fundamentals underlying their creations. Thus automobile engineering can now be really called a science. The crankcase ventilation found on all the General Motors Cars is another contribution of the research laboratory. The crankcase ventilation as applied to the Buick is clearly shown in Figures 18 and 21. Air is drawn into the crankcase through an air cleaner at the rear of the engine, and is discharged from the breather at the front along with the seepage vapors. This circulation is maintained by creating a partial vacuum in the breather. Air is blown past a venturi in the side of the breather reducing the pressure, thus drawing in air and discharging the vapor. This system is used on all the General Motors Cars except the Cadillac and La Salle, which ventilate their crankcases under pressure. Air is drawn into the crankcase on the left side and a pressure of several pounds per square inch is maintained within the case. Holes are drilled through the cylinders at their lower ends communicating with the valve chambers. Holes are also drilled in a recessed portion of the piston fitted with a special type of oil collecting ring. When the holes in the piston register with the corresponding holes in the cylinder walls, the seepage entrapped by the special piston ring is blown into the valve chamber by the pressure in the crankcase where it may lubricate the valve springs and then drain clear of the car through special tubing provided for this purpose.



PARTS OF CADILLAC CLUTCH ASSEMBLY

All springs and levers are mounted on the flywheel, giving driven member low moment of inertia.

Other mechanical changes in the Pontiac include a new carburetor, a gasoline pump with filter, and four wheel brakes similar in design to those on the Chevrolet which have already been described.

Hupmobile have redesigned their six cylinder car and are bringing out an eight with many new features.

The most important mechanical change on the six has been the adoption of Midland steeldraulic four-wheel brakes. These brakes are internal expanding, employing a one-piece shoe with a molded composition lining. This molded composition has different characteristics than woven lining so that wear is reduced materially. The brakes are self-energizing and can be adjusted outside of the housing.

The engine is built along the lines of previous models, but now has a displacement of 211.5 cubic inches. The bore has been increased to 3¼″ while the stroke is still 4¼″. The engine develops more power than its predecessor, partly because of the increased displacement, but more particularly because of a new type of cylinder head which is completely machined inside.

Again, as the result of extensive research, Hupmobile engineers have found that this particular engine developed its maximum power when the spark plug was located in the hottest portion of the combustion chamber. In view of this observation, the spark plug is located directly over the exhaust valve. The engine is pressure lubricated throughout, the connecting rods being rifle drilled to provide lubrication for the wrist pin.

The steering gear on the Hupmobile is the Ross Cam and Lever gear shown in Figure 14. This gear is unique in that the pitch of the screw varies so that in the straight ahead position the gear is irreversible, and will not transmit road shocks, while in the other positions the gear becomes reversible but then has a faster wheel travel.

Studebaker have just announced a new eight-in-line car on a 131-inch wheelbase chassis. The engine has a bore of 3⅜″ and a stroke of 4⅜″ giving a piston displacement of 313 cubic inches. The engine actually develops 100 horsepower at 3000 rpm.

The pistons are a special aluminum alloy with invar struts. The transmissions and clutch are built as a unit with the engine. The clutch is a Long unit and is equipped with their vibration damping plate. The rear axle is semi-floating, and the brakes are Bendix three shoe assemblies.

Marmon have announced two new models for the coming year, the 78, which is a medium-sized straight eight, and the 68, which is a light eight. The 78 is powered by a valve-in-head straight eight motor shown in section in Figure 15. One of the most interesting features of this engine is the duplex down draught manifolding

(*Continued on page 350*)

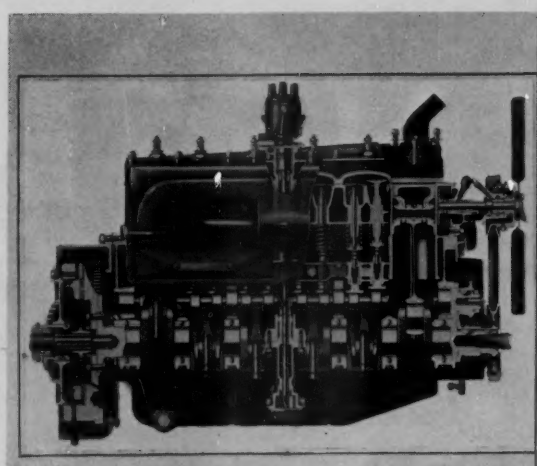


FIG. 13
Cross section of Dodge Victory Six Engine.

FIG. 14
Cam and lever Steering Gear on Hupmobile.

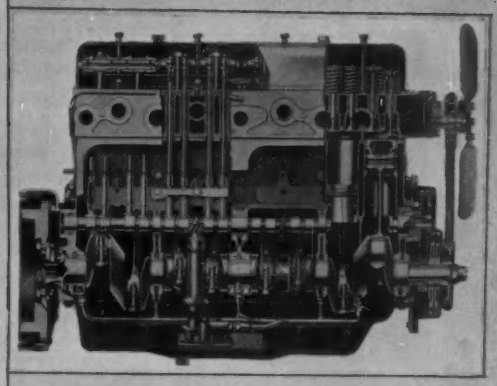


FIG. 15
Cross section of Marmon 78.

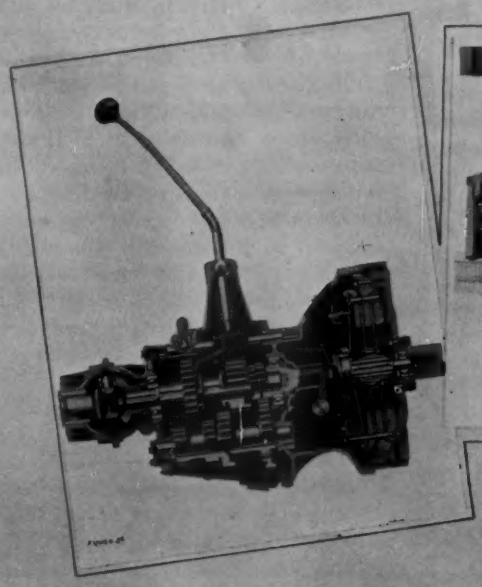


FIG. 16
Cross section of Cadillac Clutch and Transmission.

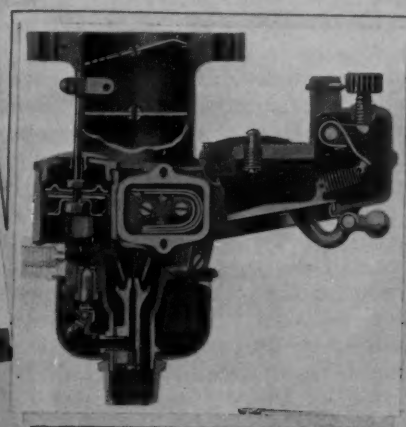


FIG. 17
Cadillac carburetor with three Thermostats.

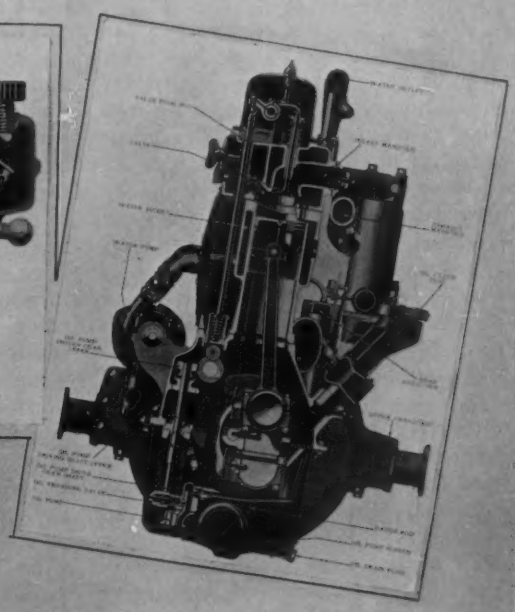


FIG. 18
Vertical section of Buick Six.

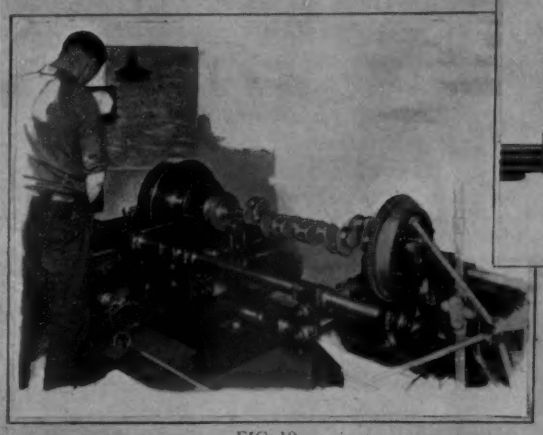


FIG. 19
Dynamic Balancing of Nash Crankshaft.

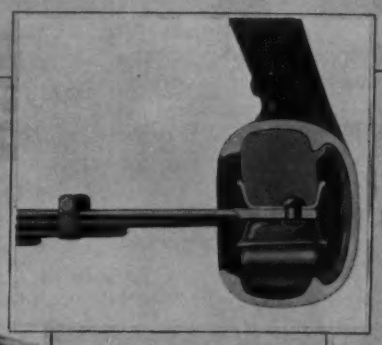


FIG. 20
Rubber Shackles used on Marmon 78.

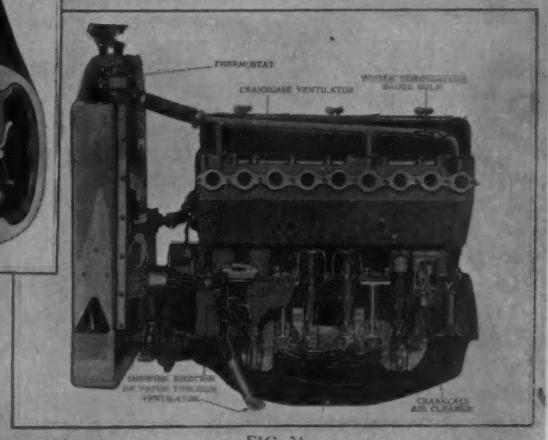
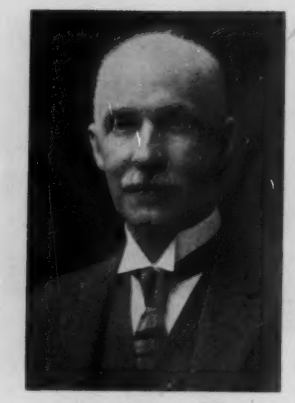


FIG. 21
Crankcase Ventilation and Thermostat on Buick.

Departmental Notes



Courtesy of *Technique*
PROFESSOR J. R. JACK

NAVAL ARCHITECTURE AND MARINE ENGINEERING

DURING the last academic year the educational work has been only of a routine character. Considerable interest is being shown by the ship operators in the Ship Operation Course, and a number of them are willing to give the students an opportunity of obtaining practical experience both at sea and ashore during the summer vacation, and also to give them employment in their offices as soon as they have graduated.

Professor Hovgaard has conducted some researches on the "Stresses of Airships Due to Bending" and has applied the results of experiments carried out last year on the deflections of bent pipes, which are somewhat analogous to those of a large airship. He read a paper on this subject at the Institution of Naval Architect's meeting in Cambridge, England, in July of this year.

Professor Burtner together with a number of the students of the course carried out some important observations on the "Deflections of Car Floats" both during launching and in operation, and obtained much valuable data which afterwards was embodied in a paper presented by him to the American Society of Naval Architects and Marine Engineers.

During the year the Nautical Museum received a few additions, the most important of which was a beautiful full model of a fruit steamer presented by Mr. D'Antoni of New Orleans. During the summer the director of the Museum visited the collection of Marine Prints and Documents which was made by Samuel Pepys and bequeathed by him to Magdalene College, Cambridge. He also visited the Science and Arts Museum at South Kensington, and spent a day with the director comparing notes on the various models. Another day was spent at the Royal Naval College in Greenwich with the professor of Naval History. These visits enabled him to clear up a number of points which were doubtful regarding the accuracy of several well-known models and marine prints which are in the Clark Collection.

PROF. J. R. JACK.

DEPARTMENT OF PHYSICS

THE Department has been fortunate enough to secure as its visiting lecturer for the year, Professor W. L. Bragg of the University of Manchester, England, known everywhere, of course, because of his wonderful work with X-rays and his more recent study of crystals.

The research work in the Department is more than ordinarily active, and has resulted during the last year in a number of interesting developments. Professor Hardy and his associates have completed their laboratory apparatus for the semi-automatic analysis of color, and publication of their work has attracted a great deal of attention here and abroad. An instrument for measuring accurately the difference in color between different samples of textiles, or different lots of flour or lampblack, or pigments, has long been needed by industry as well as by the scientific laboratories. Professor Hardy's apparatus, while not yet reduced to an instrument for commercial and industrial work, is rapidly approaching that condition.

In the X-ray laboratory Professor J. T. Norton and his associates have been doing a great deal of work upon the structure of metals with a view to determining the soundness and dependability of castings and welded pieces, and from a more theoretical point of view, to determine the effect of stresses and the results of hot or cold working, especially upon steel. Much work has been done with the new Coolidge Cathode Ray tube which the Department secured through its inventor, Dr. W. D. Coolidge, M. I. T. '96, of the General Electric Research Laboratory of Schenectady. The cathode radiations have most interesting effects upon many organic materials, and further, they produce fluorescent effects upon many crystalline materials which suggest most interesting scientific and industrial applications.

Dr. de Laszlo is continuing his investigation in the Spectroscopic laboratory upon the absorption of a great number of rare organic substances.

In the Laboratory of Heat Measurements further development work has

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PROFESSOR C. L. NORTON

gone on in the production of special refractories for very high temperature service, and a modern ceramic kiln of moderate size has been constructed to aid in the research and instruction in firing ceramic bodies at high temperatures.

In the Photoelastic Laboratory a considerable number of investigations have been carried on to determine the location and amount of the maximum stresses in engineering structures. The moving parts of internal combustion engines, the shells of boilers, and the teeth of rapidly moving gears are some of the things which have been recently under examination.

In the Acoustics Laboratory Dr. Barss is carrying on researches and investigations relating to architectural acoustics with special reference to means of correcting the acoustical properties of auditoriums.

Dr. Stockbarger is continuing his studies of the variation in the amount of ultra-violet radiation present in sunlight, and is studying the absorption of materials which may be available as a substitute for the present types of window glass which, as is well known, exclude most of the biologically beneficial ultra-violet light.

Dr. Knobel is carrying on investigations in physics and electrochemistry concerned at the present moment with problems of the protection of steam producing plants from internal corrosion. Professor Thompson has been continuing his investigations upon barium carbonate.

Several changes have been made in the set-up of Course VIII during the year, allowing a much greater latitude in the third and fourth years in the selection of subjects so that men who want to study physics, but have a special bent towards such particular subjects as optics or electricity, may emphasize the portion of physics in which they are especially interested.

PROF. C. L. NORTON.

Editorials

LOOKING BACKWARD

With this, the January issue of THE TECH ENGINEERING NEWS, the publication completes another year of its history and Volume VIII comes to a close. As we make our final bow, we should like to pause for a minute to glance back over the preceding issues of this year, to recall to mind those things which seem to us to be particularly significant.

In physical appearance, the magazine has undergone several important changes. After much experimenting with various ideas in cover design and several varieties of cover stock, we have finally settled upon the form used in the last three issues. We have tried to select those cover pictures which seemed to us valuable, not only because they furnished an example of engineering in some form, but because they had an intrinsic artistic value as well. Both the cover and inside pages are now printed upon one of the finest grades of coated paper obtainable, and this too has helped to improve the general appearance of the TECH ENGINEERING NEWS.

The editorial department of Volume VIII has undergone several changes. Winthrop H. Towner, '28, who was Editor at the start of the volume, found it necessary to resign shortly after he had assumed his position. John L. Herzog, '28, then occupied the editor's desk for the rest of the spring term. This fall, however, he did not return to the Institute, and the present Editor was elected.

Although working under handicaps, we have tried to keep the editorial material up to the traditional standard. Many men, notable in fields of engineering and science, have contributed articles within the past months. Among these may we mention Dr. G. K. Burgess, Director of the Bureau of Standards at Washington, Dr. A. C. Fieldner, Chief Engineer of the Bureau of Mines, and Dr. H. S. Cummings, Surgeon General of the U. S. Public Health Service. We have tried to publish the details of various recent important developments in the scientific and industrial world, such as the Technicolor process, the Televox system, and Television. Articles like "The Ear and the Sensation of Hearing" and "Balancing Rotating Bodies" served to present a brief summary of the general principles and theory underlying a certain familiar subject. Special feature issues, such as the Public Service and the Aviation issues have concentrated in discussing numerous sides of some important field of engineering. At all times, we have endeavored to keep in mind that to be suitable for publication an article must be not only of importance, but of interest to our readers as well.

And now, as the work of Volume VIII is finished, we should like to present our successors, the Managing Board of Volume IX: *General Manager:* William Baumrucker, Jr., '29; *Editor,* Adam K. Stricker, Jr., '29; *Business Manager,* Thomas H. Speller, '29; *Advertising Manager,* Allen A. Horne, '30; *Circulation Manager,* Charles C. Ladd, '30; *Managing Editor,* B. King Couper, '29; *Associate Editor,* Howard S. Gardner, Jr., '30; *Publication Manager,* Charles F. Edlund, '30.

THE COVER

Our cover this month is a reproduction of an oil painting depicting the Packard Twin Six engine undergoing its final tests. The painting was originally prepared for the J. L. Hudson department store in Detroit as one of a series portraying the industrial activities of the city. The whole series has been given to the Cass Technical High School of Detroit to adorn the walls of their new building.

THE ENGINEERING PROFESSION

In these columns we have previously commented in various ways concerning the duties and benefits of membership in the engineering professions and the professional societies. At the recent meeting of the A. S. M. E. in New York City, Mr. W. L. Abbott, a former president of the Society, delivered a greeting to new members which so closely exemplifies our ideas on this subject that we pass it on in full.

"You have been admitted to a great fraternity of 18,000 brothers and a few sisters, in which you are to find your place and take a part. We welcome you among us and congratulate you on your choice of a calling. But, let us ask, what was your object in seeking this alliance?

"Was it for the thrill of marching in step with a great throng? Was it the hope of personal advancement? Was it to widen your horizon and increase your knowledge in your line of engineering?

"We presume that some or all of these motives were more or less clearly in your mind, and they are all worthy motives; and yet, if they and their kind constitute all of the reasons you had for seeking membership with us, you and we will be disappointed with each other; you have forgotten the foundation stone of the column — service.

"We had hoped and we believe that by this affiliation you expected to better serve yourself, your employer, your fellows, your profession, and your fellow man. We hope that you are willing to serve your client — for a fee, yes, but willing to serve society without one; willing to help a brother engineer; willing to give of your strength, time, and talents to improve the standing of the engineering profession, and to make contributions to the sciences with which you have some acquaintance; and willing to take a citizen's part in the consideration and solution of the civic questions interesting your community.

"You have been set apart for service, not in a temple but in the broad and practical field of material things — a field of romance and adventure, of discovery and conquest, where the frontier ever recedes and never ends; where victories spell the defeat of no foeman, and gains are no competitor's loss.

"Take your place in our ranks, and although the world you serve so well accepts your gifts with scant recognition to the giver, you still have recompense in the fascination of your work, the satisfaction of creating, and the joy of serving."

PROFESSORIAL CONTACTS

Throughout their undergraduate days, many students fail completely to appreciate the personal qualities of the instructors with whom they come in contact. The professor who stands before you lecturing upon some highly technical subject might well be able to talk at equal length about the early life of some eighteenth century painter or the scenic beauties of the Alps. Only by personal contact, by conversation in leisure moments, can we come to really know those who instruct us in our future work.

The average student, however, may find it difficult to catch his professor in an informal mood, and, with the great amount of research being carried on, such exchange of ideas during Institute hours is often impracticable. We wish to compliment the Department of Electrical Engineering on their ability to make this sort of contact with their students. The Sunday afternoon teas given by Professors Jackson and Barker offer the students in Course VI an opportunity to meet and chat informally with their instructors. If the professors took for mere politeness the students' expressions of gratitude, they were deceived, for the undergraduates have enjoyed them immensely.

The Engineering Field

Abstracts from the leading professional and trade journals

A Shockless Drive for Motor Coaches is a recent invention in the automotive field. The purpose of the device is to subdue shocks from the road and from the motor, and reduce backlash, gear chatter, and jerky action at low speeds.

The construction of the drive differs from any other cushioning device so far designed for the purpose. It may be described briefly as being two steel flanges between which is a coil spring compressed at 500 inch pounds. The flanges are so bolted together that they may be twisted with respect to each other. This movement is hindered by the spring. One flange is fastened to the pinion of the differential on the rear axle and the other to the propellor shaft.

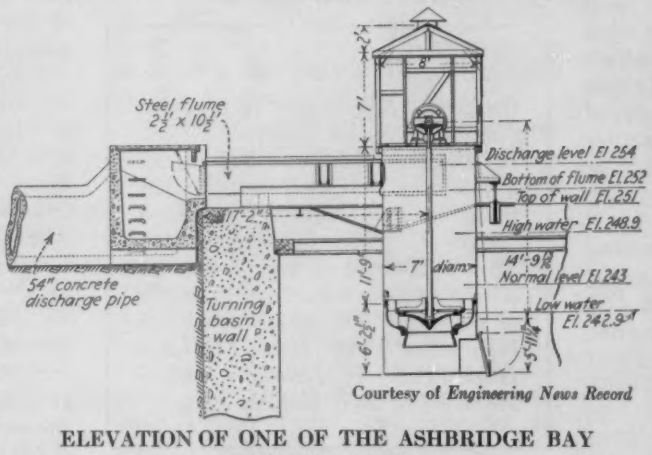
When a road shock comes to the drive it is forced back from center as many degrees as is necessary to absorb the larger part of the shock. In this manner the shock coming from the rear is reduced and is not sent forward to the motor which, without the drive, would throw a quick load on the motor and destroy its constancy. Motor shocks are handled in the same way. The rotary movement of the drive is limited to 15° on each side of center. This is a comparatively large range of action, for any previous similar device became solid within 1° to 3° from center. The spring gives an increasing progressive resistance from 800 to 7000 inch pounds. The greatest normal torque very seldom exceeds 2000 inch pounds, leaving a reserve of 5000 pounds for excessive strains.

The new drive promises to greatly improve the riding qualities of motor coaches as well as lengthen the life of chassis, motor, and tires.

Polluted Bays of Stagnant Water may be very easily cleaned and aired by means of a novel arrangement recently tried out on Ashbridge Bay, near the City of Toronto. Due to a harbor reconstruction the bay was left with only one outlet into Lake Ontario, with the result that the water became a public menace.

A steel frame was erected across a corner of a concrete turning basin wall and from it were suspended two cylindrical tanks. In each tank there was mounted a centrifugal pump which, however, is a trifle unusual in that the casing has an annular opening on the upper side to discharge the water into the tank above the pump and cause it to rise and flow through the discharge flume. The impellers are of the standard closed vertical centrifugal pump type, mounted on vertical shafts.

Each steel cylinder has a flap gate below the pump which can be closed when it is desired to empty the cylinder in order to get access to the pump. Two steel discharge tubes which are connected to the tank above the turning basin wall discharge into a concrete catch forming the entrance to a large pipe which is laid on a gradual grade to the west end of the Bay. The pump house is mounted directly on the tank taps and is supported at the ends by concrete piers from the turning basin wall.



Courtesy of *Engineering News Record*

ELEVATION OF ONE OF THE ASHBRIDGE BAY FLUSHING PUMPS

Corrosion Proof Duralumin has at last been successfully produced by government experts and at the same time by independent research. Up to this time this important aluminum alloy has had one serious drawback in that when exposed to salt air it may become brittle through a type of corrosion that is not apparent on the surface, and that cannot be detected upon inspection. This corrosion, which is termed "inter-crystalline embrittlement," weakens the bond between the crystal grams that make up the alloy.

The tests have proved, first, that by quenching the metal in cold instead of in hot water, as has been the common practice, the resistance to intercrystalline corrosion is markedly increased, and second, by giving duralumin a protecting coating of unalloyed aluminum it is possible to further insure against corrosion, as commercially pure aluminum is not subject to intercrystalline embrittlement. Specimens of duralumin covered by aluminum by the metal spray process have been exposed to salt air for a year, and are showing no signs of deterioration.

The Arens Control, which has been adopted by a number of the leading airplane manufacturers, was a control designed to replace the usual bell cranks for the transmitting of controlling forces around corners and at the same time be light and reliable. It consists of a brass sleeve of any desired length and bent to any shape, the ends of which contain a snug-fitting tube threaded to receive the control rod. There is no lost motion, the number of bends or the length of the brass sleeve appearing to make no appreciable difference in its operation. Inside the brass sleeve is a tube which is free to slide in the sleeve and inside of this is a stranded steel cable which is soldered to the tube. A steel spiral spring is inserted between the ends of the tube within the casing. A tensile force applied in one of the tubes is transmitted through the cable to the other tube while a compressive force is transmitted through the spiral spring, as there are no lateral movements in any part. Tight connections through the fire wall are permissible if desired.

Several large manufacturers have made exhaustive tests of the control which has been found to be generally superior to the other parts of the present control system. At the same time it weighs no more than the bell cranks which it replaced.

That Static is Caused by Pressure Changes in the Atmosphere is the conclusion drawn from experiments recently performed at the University of Pittsburgh.

In the experiments a glass tube containing some moist earth was connected at the top and bottom to a sensitive galvanometer. Due to the presence of weak acids in the soil a small current was indicated by the instrument. On changing the pressure of the air in the tube this current varied. Precautions were taken to prevent any effect due to pressure decreasing the resistance of the soil. When the galvanometer was replaced by an electrometer connected to the top electrode only, variation of the air pressure was found to produce an electrical charge in the electrode. This effect is believed to be due to the temporary disturbance of the electrons in

the earth when the pressure changes.

Not only static, but the related phenomena of earth currents, and the variations in the earth's magnetism which cause a compass needle to change its direction, may possibly be explained as a result of these experiments.

The Use of Cathode Rays for Drying Paint Oils has quickly followed the introduction of a more powerful cathode ray machine.

Glass plates coated with linseed oil, perilla oil, and chinawood oil were exposed to cathode rays, similar samples being exposed to blasts of warm air and beams of ultra-violet rays to note the comparison. It was found that the samples which had been exposed for ten minutes to the rays were dry to the touch in from two to three hours and hard in from five to six hours. The same material flowed on plates at the same time and unexposed to the rays was practically unchanged.

A Wire Saw for Quarrying Slate is a novel appliance recently introduced into the United States from Europe. Its use promises to eliminate great waste in this industry.

Essentially the wire saw is a three-strand wire cable running as an endless belt. This cable takes the place of the saw blade, the teeth consisting of sand grains carried in the spiral grooves formed by the twisting of the wire strands. The saw cable is carried and guided by means of orienting pulleys from the driving unit to the place where the cut is desired. Here the wire is brought in contact with the slate, and is drawn across it while being held forcibly against it. Sand is automatically fed to the saw by means of trough shaped boxes using a small stream of water as a conveyor. The sand is thus forced against the rock and dragged along with the cable resulting in rapid abrasion. The cut formed is about a quarter inch in width.

The saving of time obtained by means of the wire saw is one of its chief advantages. The slate can be cut much more rapidly than by any other known methods and with a great deal less waste of material. Another great advantage is in cost reduction. The cost by the new method is approximately one-half that involved in methods formerly employed, and further reductions are anticipated when the device is more fully perfected.

The possibility of the successful application of the wire saw in other quarrying and mining industries has been suggested. There is no apparent reason why the saw will not cut other rocks as well as slate. As a result of inquiries from these other industries the United States Bureau of Mines is conducting tests in the endeavor to give them the full benefit of this type of equipment.

Algin, which resembles starch and gum arabic in its properties, may be manufactured from seaweed, according to an announcement from California where the new industry has been established. Algin is in many respects superior to starch and gum arabic, having fourteen times the viscosity of starch and thirty-seven times that of gum arabic. It fills the cloth better than starch in sizing and finishing fabrics, and goods so treated have a thick, elastic-feel without the stiffness imparted by starch. Algin will undoubtedly find application in dyeing and color printing and in many special uses where alginic acid and its salts may be used as in pharmacy and food preparations.

A Novel Method was used by a Southern contractor in destroying the menace to navigation which was occasioned by the sinking of the steamship *Louisiana* just off the end of the South Pass jetty in the mouth of the Mississippi River. By the use of dynamite a hole was blasted under the keel of the vessel into which it was allowed to sink until it attained a safe depth.

The *Louisiana* was a steel hull cargo vessel, 253.4 feet long by 43.8 feet beam by 26 feet deep. Although it was hoped she might settle to sufficient depth, after several months, when it was evident that settlement had ceased, the stern still projected four feet above water while the bow rested at a depth of 15 feet. After an unsuccessful attempt to remove the wreck by forcing air into the hull, bids were advertised to have the work done by contract.

Work was started with a plant consisting of a power-driven lugger, 75 feet long by 24 feet beam with six feet draft. The crew consisted of a master, an engineer, and two deck hands, in addition to which a powder foreman and five laborers were employed. An anchor was fastened to a one-inch manila rope to which cases of 60 per cent straight dynamite and some gelatin were strung at about two feet intervals until a total of 5,100 pounds had been attached. The anchor was dropped at a point just above the bridge of the vessel and then the rope with its charge of dynamite was pulled taut about the keel, distributing the charges evenly right up to the stern. The charge was then fired from a rowboat.

The result was that a hole was made beneath the vessel into which it settled. This preliminary charge caused a settlement of about nine feet. The process was repeated until the wreck was well below the surface of the water. Then smaller charges were exploded directly over it in order to flatten it. In this manner the wreck was sunk to a depth below 35 feet.

The work was completed within seventeen days with a total consumption of 28½ tons of dynamite.

The Purification of Water by Chemical Means has heretofore been ineffective in removing sodium and potassium salts. While these compounds are not harmful for ordinary purposes, certain processes forbid their use. Distillation has been the usual means of ridding water of all its solid content, but a new process, called electroösmosis, does the same work at a fraction of the cost expended in distillation.

The apparatus consists essentially of a series of cells, each cell divided into three portions by two diaphrams. The middle portion of the cells are connected by siphons; the outside contain electrodes. Water is passed through these cells, as well as an electric current. This current causes the ions of the compounds to move toward their respective electrodes, the diaphrams admitting their free passage. The pure water left in the middle cell passes on. The process is repeated throughout the whole series of cells. Each time the water leaves a cell it conducts electricity less readily. This necessitates each succeeding cell having a higher voltage through it.

The product is entirely satisfactory for use in laboratories, storage batteries, for pharmaceutical work, etc. It is hoped that the developments may prove the process practical for use in preparation of boiler-water, artificial ice, and other large-scale applications.

Courtesy of Industrial and Engineering Chemistry

THE PURIFICATION OF WATER BY ELECTROÖSMOSIS

Automotive Developments for 1928

(*Continued from page 344*)

system. The manifold has two distribution systems, one taking care of cylinders 1, 2, 7 and 8, and the other of cylinders 3, 4, 5 and 6.

Distribution is one of the most important problems facing the research engineer, and the straight eight has been especially difficult. The manifolding on the Chandler Royal Eight is shown in Figure 5, which represents another solution to the problem. So far the V eight, when properly designed, has been superior to any straight eight for efficient distribution. The V eight has short passages for the charge, and passages of more equal length, as the gas does not have to travel as far, the gas velocity tends to be lower, and the inertia effect is considerably reduced. The left block of the Cadillac is shown in the sectional view of the engine in Figure 4. This shows the short manifold and the exhaust jacket surrounding the portion of the manifold connecting the two blocks with the carburetor.

The Marmon 78 has a bore of $2\frac{15}{16}''$ and a stroke of 4", with a compression tatio of 5.5 to 1. The pistons are a modern design split skirt lynite casting. The split skirt can be seen in Figure 15. The car is hung very low and built to maintain high speeds. Figure 8 is an elevation of the chassis, showing the very low overall height. This construction is enhanced by the use of Hypoid gears in the rear axle. The springs are mounted in rubber cushions which are shown in Figure 20.

The Marmon 68 is a small L-head eight of conventional design. The rear axle and brake mechanism are shown in Figure 3.

One of the outstanding developments in the high-priced field this year has been the introduction of the La Salle and 341 Cadillac by General Motors. The two cars are very much alike, and the engines are identical, except for a slight difference in bore. The cylinder dimensions of the Cadillac are $3\frac{5}{16}''$ x $4\frac{15}{16}''$ while the La Salle is $3\frac{1}{8}''$ x $4\frac{15}{16}''$. These engines are a further development of past Cadillac practice which has set a standard for the industry for a great many years. The connecting rods are now placed side by side, and the blocks have been staggered slightly. This was done to secure better lubrication for the connecting rods. An interesting feature is the die cast aluminum piece which is screwed into the crankpin to carry oil to the bearings. This is shown in Figure 4. A vacuum pump is now mounted at the rear of the engine to supplement the vacuum tank. This is driven by an eccentric on the camshaft.

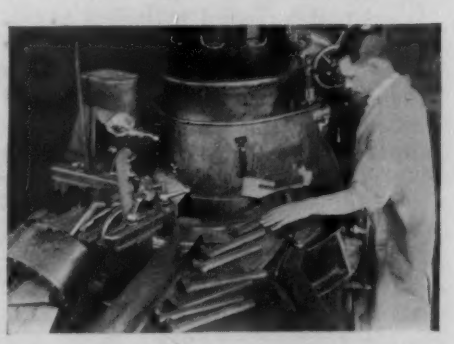
The clutch on both the Cadillac and La Salle has been redesigned to reduce the moment of inertia of the driven member. This clutch is unique in that all springs, levers, and other parts of the clutch, with the exception of the clutch thrust bearing, are carried on the flywheel. The clutch thrust bearing is carried on the transmission case. A cross section of the clutch and transmission is shown in Figure 16, and the disassembled clutch is shown in Figure 22. The engine on the Cadillac is now supported in rubber lined mountings at the rear and by a ball and socket joint on the front cover plate. The rear axle is of a full floating type on the Cadillac, and a three-quarter floating type on the La Salle. In both cars the drive is through a torque tube relieving the springs of all duties except supporting the car. Figure 7 is an excellent cross section of the Cadillac axle.

One of the engineering developments Cadillac introduced in the fall of 1921 for their type 61 car is the thermostatic control of the carburetor as shown in Figure 17. This carburetor is very simple in construction, but highly efficient. A concentric float chamber is used to eliminate insofar as possible interference with carburetion from the car not being on a level. There are three thermostats in this carburetor. One controls the action of the auxiliary air valve, one regulates the action of the throttle pump, and the third opens a vent to relieve gas pressure at very high temperatures. A throttle pump is provided for rapid acceleration.

These two cars are excellent examples of a highly developed piece of machinery designed insofar as possible on well-founded scientific principles. The whole industry is constantly tending to utilize science to secure better performance, lower cost, and longer life.

Other interesting developments of the past year were a new type of valve spring on the Packard, very extensive use of aluminum on the Pierce-Arrow, and a larger engine on the Lincoln.

The general tendency during the past year was to increase engine performance by using higher compression ratios in conjunction with special cylinder heads as already outlined. Chrysler have increased their compression considerably. Many of the new models should really be run on Ethyl gas to receive the best results. Greater care has been taken to balance engines and other rotating parts than formerly, so as to reduce vibration. Figure 19 shows the balancing of the Nash crankshaft. All of these advances have been made to increase the usefulness of the automobile to the American public, and in most cases they have been made at no increase in cost.



BLANCHARD AUTOMATIC SURFACE GRINDER

The automatic surface grinder consists of a vertical motor-driven spindle carrying a large cup-shaped grinding wheel and a motor-driven special magnetic chuck which holds the work.

One passage under the grinding wheel finishes one surface of the work. To finish two sides, the work must pass through the machine twice, which is done by running through a quantity, usually several thousand pieces, with the machine set to leave sufficient thickness for grinding the second side. The machine is then set for the finished thickness and the work passed through again.

The wheel control caliper controls the feed of the grinding wheel to maintain a uniform thickness of work.

By a simple arrangement of magnets, having no contact devices or moving coils, the chuck face is caused to be strongly magnetic just after receiving the work and continues so under the grinding wheel and the caliper. At the unloading point it loses all magnetism and continues so through the cleaning and loading points.

After the pieces leave the machine they pass through the demagnetizer into the washing machine which cleans the pieces for the next operation. Arrangements are also made for holding work mechanically.

The parts that may be ground in this machine are numerous and among them are castings, ball bearing rings, valve seats, forgings, armature dies, automobile pistons, hardened steel cutters, magnets, reamer blades, small tools, washers, valves, dies, etc.

PROF. R. H. SMITH.

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BELL SYSTEM — AMERICAN TELEPHONE & TELEGRAPH CO. AND ASSOCIATED COMPANIES

Western Electric

SINCE 1882 MANUFACTURERS FOR THE BELL SYSTEM

Theories of Disease Immunity

(*Continued from page 334*)

reduced from about 35 per cent to less than 10 per cent by the use of antitoxin and might be further reduced to practically zero if antitoxin were used early and in sufficient quantity in every case. Diphtheria antitoxin is also given in smaller doses as a prophylactic to those exposed to the disease and is very effective, but the protection is only for a few days.

Immunity conferred by the introduction of antibodies in a foreign serum is spoken of as a passive immunity, since the body cells of the infected person are not concerned in its production. In contrast with the antibodies of active immunity, those of passive immunity are quickly disposed of and their value for protection or cure is expended within a short time.

Schick discovered that it was possible to tell whether a child was susceptible to diphtheria or not by introducing a tiny dose of diphtheria toxin into the skin. If the child was protected by the presence of "natural antitoxin" there was no reaction. If he was susceptible, a local inflammatory reaction of short duration followed, due to the action of the toxin on unprotected tissues. Susceptible children will usually develop an active immunity if given three injections of an over neutralized toxin-antitoxin mixture. The immunity is slow in appearing and may require several months, but seems to be permanent thereafter. This method has been applied chiefly in the public schools and has had a marked effect in decreasing the incidence of diphtheria. There is great need that it be universally adopted for a much more susceptible group of children, those of pre-school age. By its aid we may hope to make diphtheria a rare disease.

The organism causing tetanus or lockjaw produces also a soluble poison, the strength of which may be judged by the fact that a single cubic centimeter may contain enough to kill 50,000 to 75,000 guinea pigs. Against lockjaw, tetanus antitoxin is the only specific remedy, but for its most effective use it must be given when the wound is received rather than after symptoms have developed.

Through the researches of Drs. Dick and Dick of Chicago, 1923, the organism causing scarlet fever, a streptococcus, has been isolated. It also has been found to cause disease by soluble toxins, and all the armament available against diphtheria can now be used against scarlet fever. Antitoxin for its cure or as a protection against recent exposure; Dick tests for susceptibility; toxin inoculations for the production of active immunity; all await proper direction and use.

Antiserums for other diseases, erysipelas, epidemic meningitis, certain types of pneumonia are also available and extremely valuable. It is interesting to note that in the field of animal poisons, notably snake venoms, similar antiserums have been produced by inoculation of animals with the poisons. These antiserums are in successful use in countries where the menace of poisonous snakes exists.

In any use of an antiserum we have to remember that in addition to the specific antibodies we are introducing a foreign protein, *i.e.*, horse serum. With susceptible persons, especially sufferers from hay fever or asthma, the introduction of a foreign serum may be followed by severe respiratory difficulties. Such persons may be "desensitized" by inoculation of frequent small doses. A more common effect of horse-serum injections is the so-called "serum disease," an urticarial itching rash which appears eight to ten days after the inoculation, and is more annoying than harmful.

Where the organism of a disease has not been discovered and so the production of antiserums in animals is not possible, helpful effects may be brought about in some diseases by giving the sufferer inoculation of the blood serum of convalescents from the same disease.

Measles is a very fatal disease in young and delicate children because of its tendency to complication with broncho pneumonia. Inoculation of such children, after exposure to the disease, with the blood serum of convalescent persons, or even with any adult serum, has been very successful in warding off the disease, or in causing the infection to assume a mild form. The cause of measles is yet unproven, but there is much recent work pointing towards the probability of there being a measles streptococcus. Experimental antiserums have been produced by inoculating goats and horses with this organism, and it is hoped that a specific animal antiserum may soon be available which will do away with the difficulties of obtaining it from human sources.

With infantile paralysis, experimental work indicates that the serum of convalescents if given early in the disease may prevent the development of paralysis. No benefit is to be expected from its use after paralysis occurs.

Besides antitoxins we frequently find such antibodies as agglutinins, precipitins and cytolysins.

The action of agglutinins, as the name implies, is to agglutinate the specific bacteria which caused their formation, for example, typhoid bacilli in a broth culture are rapidly motile organisms each pursuing his individual way; when, however, a drop of such a culture is mixed with a drop of diluted blood serum from a person ill with the disease the bacteria quickly lose their motility and gather together in clumps.

The same specific reaction takes place in various other infections, so that by keeping cultures of the various pathogenic bacteria on hand we can test them out against the blood serum of the patient and so determine the identity of the specific antibodies caused by the infection. Conversely, if we have isolated a supposed pathogenic organism from the patient we can test it against various stock antiserums and determine its identity. Both methods are in daily use in modern laboratories and the results are dependable.

Precipitins in blood serum, cause precipitation when mixed with the soluble products of the growth of the specific bacteria. They can be produced in the blood of laboratory animals by inoculation of any soluble protein and are specific for the protein used. They can also be produced to act against blood serum of different species. Laboratory tests have been devised not only for identification of disease by precipitin tests but such tests have also been used for accurate work on determination of animal species and groups. In court cases where it becomes necessary to determine if a blood stain is of human origin precipitin tests are relied upon.

Bacterio lysins dissolve the specific bacteria responsible for their production. Lysins can also be produced against other cells, red blood cells for instance, by inoculating an animal with repeated small doses. Such lysins will be specific against the particular type of cell used. Antibodies of this type are made use of in such complicated, though practical, tests as the Wassermann test for syphilis or complement fixation tests for gonorrhoea and other diseases.

In the brief period of time that has elapsed since the first productive studies along this line more has been accomplished in the way of accurate diagnosis, prophylaxis and cure of infectious diseases than in all the previous period of human existence. Much remains to be done, many hard problems are yet unsolved, but we hope to see in the years soon to come the fulfillment of Pasteur's prophecy, "It is within the power of man to banish infectious disease from the earth."

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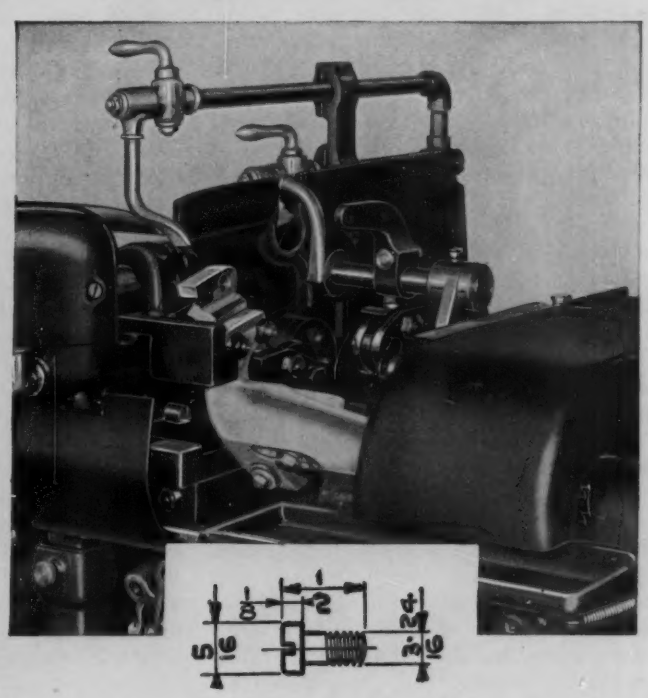

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The Televox

(*Continued from page 341*)

tion of a stepping magnet and selective switch. This portion of the Televox equipment answers the telephone at the substation and informs the dispatcher at the central station that he has the right number.

All contacts are shown in the position that they normally occupy when the Televox is not in use. Another stepping magnet which receives impulses from the receiving set operates selective switches which control the substation equipment.

A more detailed explanation of the construction of the Televox may be obtained by following through the various steps involved in performing a simple operation. For example, the dispatcher may wish to close circuit breaker number two in substation number four. He calls the telephone exchange in the usual manner and asks central to ring the telephone at the substation.

When the bell at the distant station rings, the bell ringing relay furnished by the Telephone Company gives the initiating impulse to the Televox by closing a master relay. This master relay energizes several circuits which in turn operate the weight-lifting magnet, close the filament circuit of the amplifiers, energize a time delay relay, start a buzzer and a stepping magnet. (See figure 3). The stepping magnet operates four selective switches one of which makes and breaks the howler circuit four times, signaling the dispatcher that he is connected to substation number four. If the Televox receives no further commands, the signal is repeated two or three times until the time delay relay trips the master relay restoring all of the apparatus to normal position.

The vibrating armature of the buzzer causes a pulsating current in the primary of the transformer 3. The secondary of the transformer is connected in series with a selector switch 2 and a howler or loud speaker. The stepping magnet lifts a pawl from a ratchet that is mounted on a shaft carrying the selector switch. (See 2.) The stepping magnet also closes the circuit of relay number 1 which in turn energizes the slow release relay. The slow release relay opens the stepping magnet circuit releasing the pawl and interrupting the circuit of relay 1. When the pawl is released, it turns the ratchet and advances the selector switch 2 one step, closing the howler circuit. When the circuit of relay 1 was opened, it de-energized the slow release relay. After a short time interval the slow release relay releases its armature and closes the stepping magnet circuit, starting another cycle. About one second is required for each complete cycle or step. As the selector switch is advanced, it alternately makes and breaks the howler circuit, sending out a signal of four buzzes.

After all desired operations have been performed a 600 cycle note is transmitted by the dispatcher to the ear of the Televox. This 600 cycle impulse passes through amplifiers, filter circuits, transformers and rectifiers to a restoring relay. The restoring relay trips the master relay and energizes relay 4. Relay 4 connects the back contact of the stepping magnet to the positive side of the battery. The stepping magnet then operates as a buzzer and spins the selector switch around to its normal position. When selector switch 2 comes to its normal position another selector switch that is carried on the same shaft opens the

(*Continued on page 360*)

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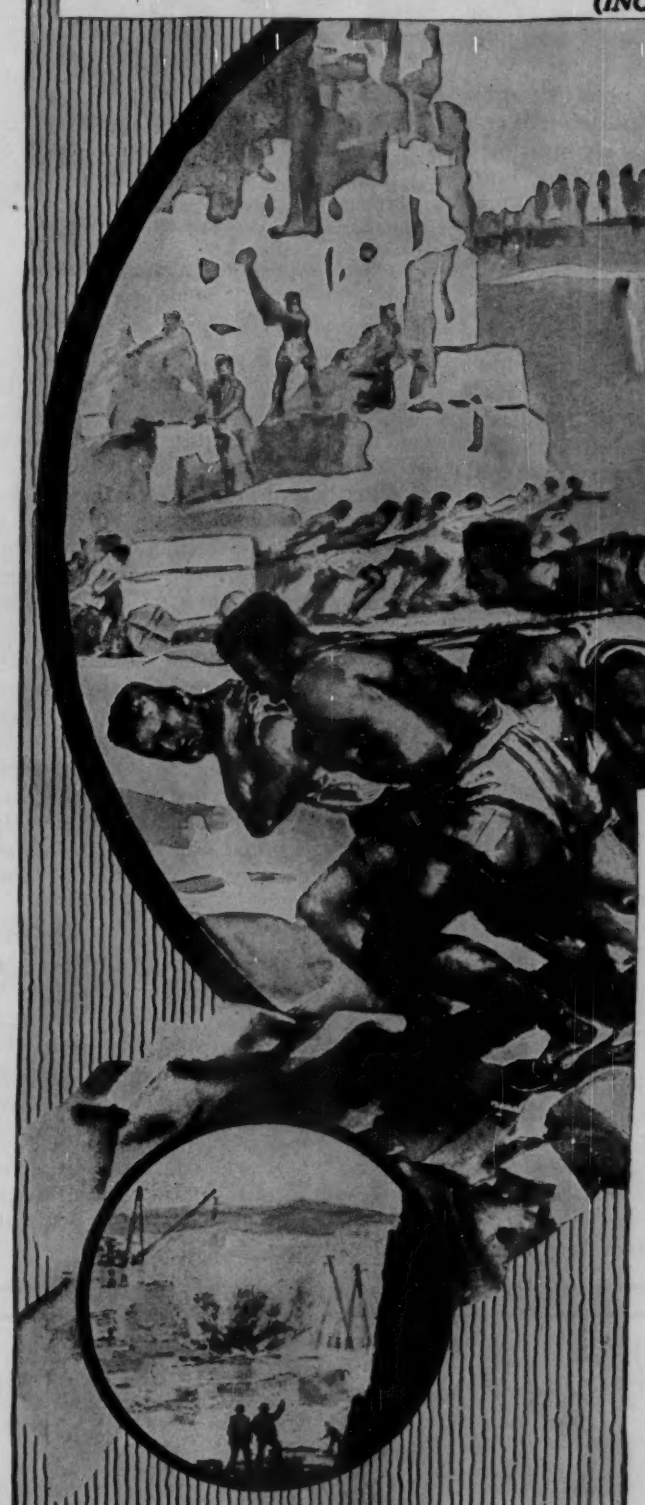

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In 402 B. C., Dionysius the Elder—tyrant of Syracuse—began to build a wall about his city. 7000 Athenian captives labored under the lash to quarry the rock; at one time 60,000 workmen with 6000 yoke of oxen were at work on the structure itself; and yet it took seventeen years to quarry the stone with which this wall, only six and one-half miles long, was built.

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1405

The Transmission of Heat by Gas Radiation

(*Continued from page 335*)

whose radiations are sufficiently strong to merit consideration in engineering calculations. Moreover, carbon monoxide and the hydrocarbons are present in such small concentrations in combustion products as to be negligible compared with water vapor and carbon dioxide. Sulphur dioxide does occur in large concentration in the coolers following a sulphur burner, but the data on the infra-red spectrum of SO_2 are inadequate as a basis of calculation of heat transmission. The following treatment, then, will be concerned only with water vapor and carbon dioxide.

The energy radiated from a gas mass to a unit area of its bounding surface in unit time is a function of two variables, one of which is gas temperature, the other a product term PL, in which P is the partial pressure in atmospheres of the radiating constituent (CO_2 or H_2O), and L is the "effective thickness" of the gas layer, a term to be considered later. The relation among T, PL, and energy radiated is of so complicated a nature as to require presentation in the form of a family of curves rather than as an equation. Two such families of curves are presented in Figures 1 and 2, for carbon dioxide and water vapor, respectively. Each line represents the relation between temperature along the abscissa and heat transmitted, B.t.u. per square foot per hour, along the ordinate, for a constant value of the product term PL. If we let C be the B.t.u. per square foot per hour radiated due to carbon dioxide, with a subscript g to indicate gas temperature or s to indicate surface temperature, and let W be the corresponding notation for water vapor, the heat-transfer equations are

$$Q/\theta = A \cdot p_s \cdot (C_g - C_s), \text{ due to } CO_2 \quad (1)$$

and

$$Q/\theta = A \cdot p_s \cdot (W_g - W_s), \text{ due to } H_2O \quad (2)$$

in which Q/θ is B.t.u. per hour, A is the receiving-surface area in feet, p_s is the black-body coefficient or emissivity of the receiving surface. C or W for the proper value of PL and T is determined from Figures 1 and 2.

When both gases are present simultaneously, their individual effects can be added only under certain conditions. Carbon dioxide and water-vapor both have an emission band at 2.7μ, and the intensity of energy emission at that wave-length by the two gases combined is less than the sum of their individual intensities. When the gas layer is thin, the values of Q/θ from equations (1) and (2) may be added without appreciable error. For thick gas layers a correction is necessary. Because of the complicated nature of the correction term an alignment chart, Figure 3, has been provided for determining it. The total radiation from a gas to its bounding surface is then given by

$$Q/\theta = A \cdot p_s \cdot \left\{ \begin{matrix} (C_g - C_s) + (W_g - W_s) \\ -(K_g - K_s) \end{matrix} \right\} \quad (3)$$

in which K is the correction term from Figure 3, where it is labeled $Q/A\theta$. It will be found that when

$$L(4.9P_{CO_2} + 6.5P_{H_2O}) < 0.3$$

the correction term is negligible.

The product term PL contains the term "effective thickness" of gas layer L. Since the radiation from a gas to its bounding surface proceeds from all points in the gas towards the surface, it is apparent that the length of travel of the radiant beam varies with its angle of incidence. The "effective thickness" is the proper average value of that length of travel of the beam to the surface, for the gas shape in question. It is outside the province of this paper to indicate the method of determing "effective thicknesses" for various gas shapes; the results are presented in Table I.

TABLE I. EFFECTIVE THICKNESSES FOR VARIOUS GAS SHAPES

Description of shape	*Effective thickness, L*
Sphere	$\frac{2}{3}$ × diameter
Infinite cylinder	1 × diameter
Space between infinite parallel planes	1.8 × distance between planes
1 × 2 × 6 rectangular parallelopiped, radiating to one of large faces	1.3 × smallest dimension
Cube	$\frac{2}{3}$ × side
Space outside infinite bank of tubes with centers on equilateral triangles; tube diam. = clearance	2.8 × clearance
Same as preceding, except tube diam. = $\frac{1}{2}$ clearance	3.8 × clearance

For example, if we are considering the radiation from hot gases to boiler tubes, the effective thickness L of the gas layer is 3.8 times the clearance between tubes, expressed in feet.

When there is a large drop in temperature of the gas from entrance to exit end of its passage, the question arises as to the proper average gas temperature to use for T_g, in terms of entrance- and exit-gas temperatures. The problem has been solved exactly by graphical integration, and the results are given in another paper where it is shown that, within the limits of error in other terms, the average gas temperature may be taken as equal to the surface temperature plus the logarithmic mean temperature difference of gas and surface. In other words

$$T_g = T_s + \frac{T_1 - T_2}{2.3 \log \frac{T_1 - T_s}{T_2 - T_s}}, \quad (4)$$

in which T_g is the average gas temperature, T_1 and T_2 are entrance and exit gas temperatures, and T_s is surface temperature.

Although heat transmission from gases does not follow the Stefan-Boltzmann fourth-power law with re-

(*Continued on page 364*)

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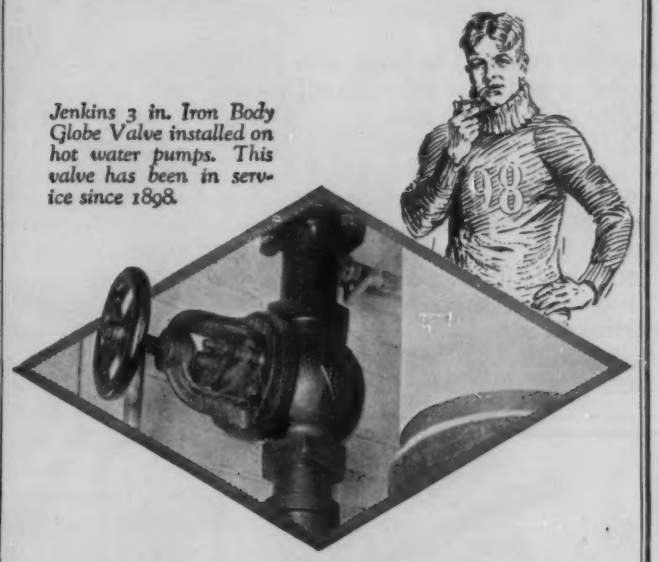

Jenkins 3 in. Iron Body Globe Valve installed on hot water pumps. This valve has been in service since 1898.

A Jenkins Valve "Class of '98"

This Jenkins 3" Iron Body Globe Valve was made in 1898 and has seen continuous service since that time in the New York City works of R. Hoe and Co., Inc., world's largest manufacturer of printing presses. The photograph, which is unretouched, shows the valve installed on hot water pumps. This valve is one of a good-sized number of Jenkins "Class of '98" valves in use at the Hoe plant.

The performance of these "ninety-eighters" can be matched in hundreds of industrial installations throughout the country where veteran Jenkins Valves are on the job. Instances are not uncommon of Jenkins Valves which are still in service after thirty, thirty-five and even forty years.

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Fig. 325
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Television

(*Continued from page 337*)

sponding point. The thing seen at the receiving end thus shapes itself into a replica of the scene sent.

A clearer conception of the mechanism may be gained by following the process through step by step. The first hole of the sending scanning disk enters the rectangular field at one corner and throws its dot of light on the corner of the scene. Light, proportional to the brightness of the scene at that point, is reflected to the photoelectric cells and transmitted as a proportional current. At the receiving end this current causes the neon tube to glow with an equivalent brightness. At the same instant the first hole of the receiving scanning disk has just entered its rectangle and the watcher sees the neon tube through it, or what appears to be a dot of light at the corner of the rectangle.

The same sequence is carried through for each position of the fifty holes of the scanning disk. A hole on the receiving disk is always in the same relative position as the corresponding hole of the sending disk, and the neon tube, at each instant, glows with a brightness corresponding to the part of the transmitted scene on which the dot of light from the disk falls at that instant.

The success of the method depends on very close synchronism between the two scanning disks. It is necessary to hold them in the same relative position to within a ten thousandth of a revolution. The scene to be sent is divided into 2,500 elemental areas, and individual scenes differ only in the relative brightnesses of these small areas. The whole identity of the received scene depends on the correct relative brightness being indicated at each spot. Should the relative brightnesses become disarranged, as they would were the two disks not in exact synchronism, the received scene would no longer be a duplication of that sent.

It is well to keep in mind the two basic steps necessary to the accomplishment of television: the reciprocal transformation of light to electricity, and the spacial arrangements to temporal sequences. Each step is required for both the transmitting and receiving apparatus but the direction of transformation in one case is the reverse of that in the other. There is a third step required at the receiving end. This is a time-integration which is accomplished by the "persistence of vision" of the eye.

It happens that the apparatus used to accomplish the transformation of spacial arrangements to temporal sequence is reversible so that a similar piece of apparatus may be used for each terminal. The apparatus for the transformation of light to electricity is not reversible so that for this function two separate pieces of apparatus are necessary: the photoelectric cell to change light to electricity and the neon tube to change electricity to light. Thus three distinct pieces of apparatus in all are necessary for the success of television.

This is, of course, only the framework of television. A large amount of special apparatus and circuits are necessary to bring the whole into reality. The scanning disks are each driven by the equivalent of three motors: one to supply driving power, one to insure the two disks locking into step in the proper space relationship, and one for synchronizing. The latter is special and of an entirely new design.

The current from the photoelectric cell is exceedingly small and must be amplified some ten-million-million fold by vacuum tube amplifiers. The varying current transmitted is composed of all frequencies up to infinity, which presents a transmission problem of no inconsiderable magnitude.

So the difficulties multiply. Each major problem is divided into many more minor ones and each minor one has its lesser difficulties. The whole has required a large amount of study and experimentation and many members of the technical staff of Bell Telephone Laboratories have been engaged in the work at one time or another.

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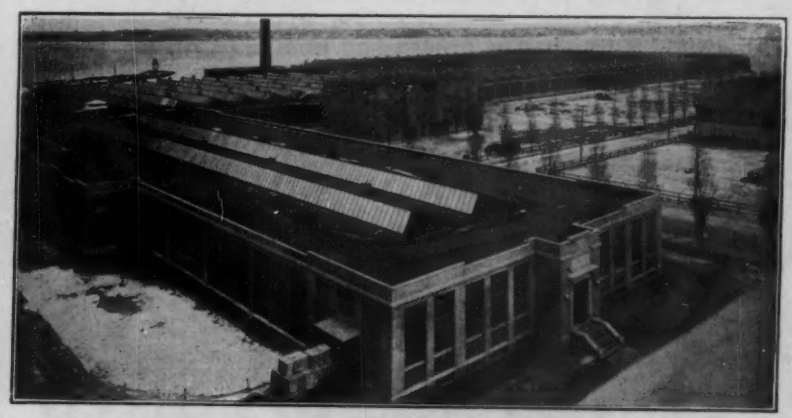

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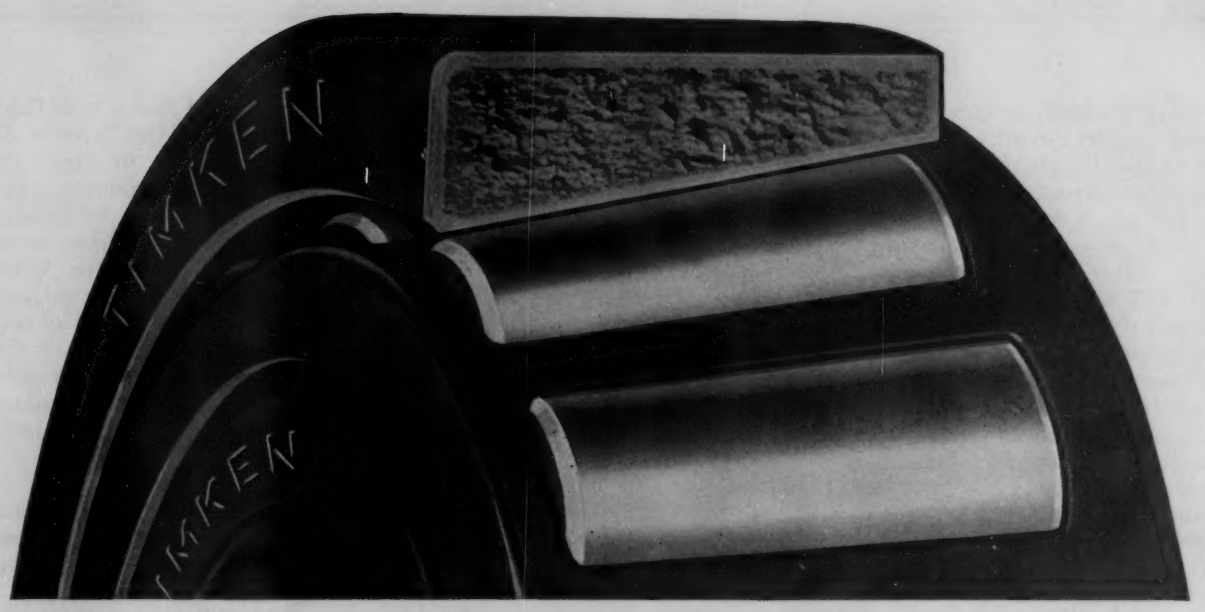

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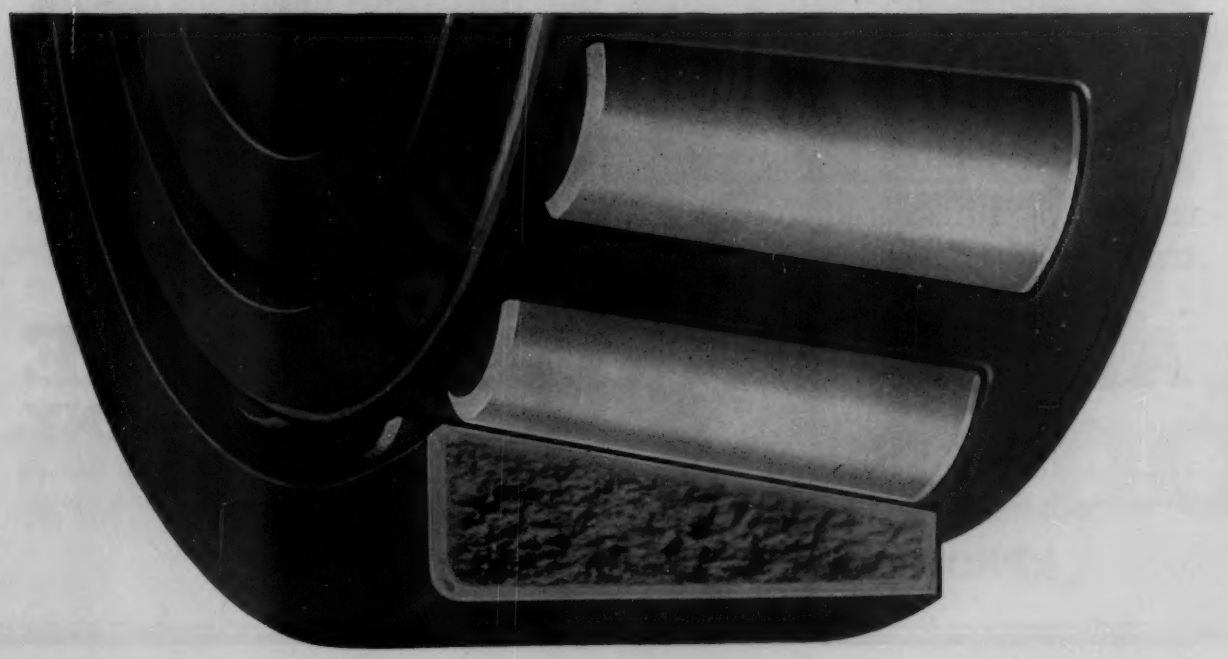

The Televox

(*Continued from page 354*)

circuit of relay 4 which, in turn, opens the stepping magnet circuit.

As soon as the dispatcher is assured that he has the correct substation on the line, he sends one 1400 cycle impulse which de-energizes the time delay relay. After this operation the equipment will not "hang-up" until told to do so by the dispatcher.

Another stepping magnet similar to the one shown in this diagram is used to select control circuits. The second stepping magnet advances a group of selector switches one step each time the Televox receives a 1400 cycle impulse from the dispatcher.

To select breaker number two, the dispatcher transmits two 1400 cycle tones to the receiver of the distant phone. From the telephone receiver the impulses are transmitted through the microphone or ear, amplifier, filter circuits, and telephone relay to selective switches. The selective switches transmit a code of buzzer notes giving first the number of the device selected, to check the accuracy of the selection and the position of the device.

If the breaker is found to be open the dispatcher may close it by impressing a single impulse of 900 cycles on his transmitter. If the breaker is closed, the dispatcher may open it by impressing a similar 900 cycle note, or he may step the selector past the breaker position with the 1400 cycle note. After the breaker changes position, an interlock relay on the breaker operates the buzzer code generator and transmits the information to the dispatcher.

A single line diagram of the Televox circuits is shown in figure 4.

It is at once evident that numerous modifications and extensions of the very simple scheme here outlined are possible. Several methods are available for reading meters and pressure gages, observing the position of gas valves, reading height of water, or observing temperature. The Televox may be used to transmit this information over the telephone to an operator.

A small portable Televox unit or whistles of the proper pitches may be carried by repair men. After a broken feeder or a short is repaired, the service men can call the substation from any telephone to close the feeder breaker and restore service.

It is believed that a wide field of usefulness exists for the Televox, although not to the extent to which the vivid imaginations of the newspaper reporters would lead one to believe. The uses in the home which appealed so widely to the feature writers are obviously things of the rather distant future. There are plenty of uses in the public utility field to justify the active development of this device without extending its uses to the management of the home by remote control.

Rhenium the new chemical element which has recently been discovered, has now been obtained in the pure form. The element was first detected by the discovery of the characteristic lines in the X-ray spectrum. Now, by a long and difficult refining process, a small quantity of the substance has been obtained by the original discoverers. It is described as having a high melting point and as uniting readily with a number of other elements. In an atmosphere of pure oxygen it ignites easily, forming a white oxide.

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Industrial Plant Dust Explosions

(*Continued from page 339*)

and force. Some destructive explosions have been heard but a short distance away. In other instances the concussion has been so great that the explosion has been heard and damage has been done to property a considerable distance away. Reports state that an explosion in a flour mill at Litchfield, Illinois, in 1893, was heard 25 miles away, and that almost every house in the village was damaged. People 70 miles away heard the explosion which occurred in a starch factory in Cedar Rapids, Iowa, in 1919, and one woman, living in a town at least 100 miles away, stated that she heard the explosion. The shock of an explosion in a large grain elevator at South Chicago, Illinois, was distinctly felt in Benton Harbor, Michigan, more than 50 miles away, and it was reported that it was heard by persons 100 miles from Chicago.

One peculiar phenomenon is that frequently dust explosions are not heard by many of the employees working in the plant. An explosion in a Middle West factory reported to have been heard at a great distance was not heard by a man in the boiler plant which was not far from where the explosion originated. In an explosion in a grain elevator, one of the men in the basement stated that he did not hear the explosion, although he was thrown down by the force of it. In some instances workmen who have been injured by explosions have not heard the reports, whereas people near the plant have heard as many as three reports.

Direction of Explosion Force

From a study of a large number of industrial plant dust explosions, it is reasonable to conclude that the force is exerted equally in all directions and that it seems to take one particular direction only because the walls on that side may be weaker and give way more readily. This is an important observation since it has been suggested that the force of a dust explosion is usually in a lateral direction. In an explosion in a large factory, a keen observer estimated that flames shot fully 500 feet into the air. Debris was picked up more than 2½ miles from the plant.

Although it may seem contradictory, it appears that part of the destruction caused by a dust explosion in a mill may be the result of suction rather than of pressure. After an explosion the very high pressure developed falls rapidly and often a high vacuum is formed. A peculiar condition was noticed in an explosion in a large terminal grain elevator. One employee standing close to a door in the basement of the elevator on the side opposite the boot of the elevator in which the explosion started was blown out through this door against a pillar a few feet away. This indicates definitely that pressure was exerted in the basement of the elevator. The property damage in this part of the building, however, showed that a strong vacuum, as well as much pressure, was developed. The basement had windows on three sides. Most of the glass of these windows was blown from the sashes, but instead of being blown out, which would indicate pressure, it was found in small pieces all over the floor of the basement, indicating that it was drawn in by suction. That this suction was great was shown by the fact that some of the glass was found from 30 to 40 feet from the walls. It is not unusual in dust-collecting systems and conveyor pipes for a pipe to collapse, instead of being blown apart by the pressure within. That many walls have been drawn in instead of being forced out proves that a great deal of damage to property is the result of suction rather than of pressure.

Plant Design and Construction

Plant construction has a very close relation to the origin and extent of the explosion. In a number of explosions the value of certain types of construction, for example, large window glass areas, has been well demonstrated. In the design and location of an industrial plant it is essential that the engineers give full consideration to the importance of this matter. In the design of a chemical plant, for instance, it will be found that the dust explosion hazard exists in processes of almost all types, such as transporting, energizing, reacting, separating and conditioning. In the transporting process explosions may originate in the elevators, conveyors, loading and unloading machines, and in handling and conveying equipment of almost all kinds.

In the separating process, explosions have occurred in the operation of separators, collectors, sifters, and similar machines. When we reach the conditioning process we find that explosions have occurred in grinders, crushers,

(*Continued on page 364*)

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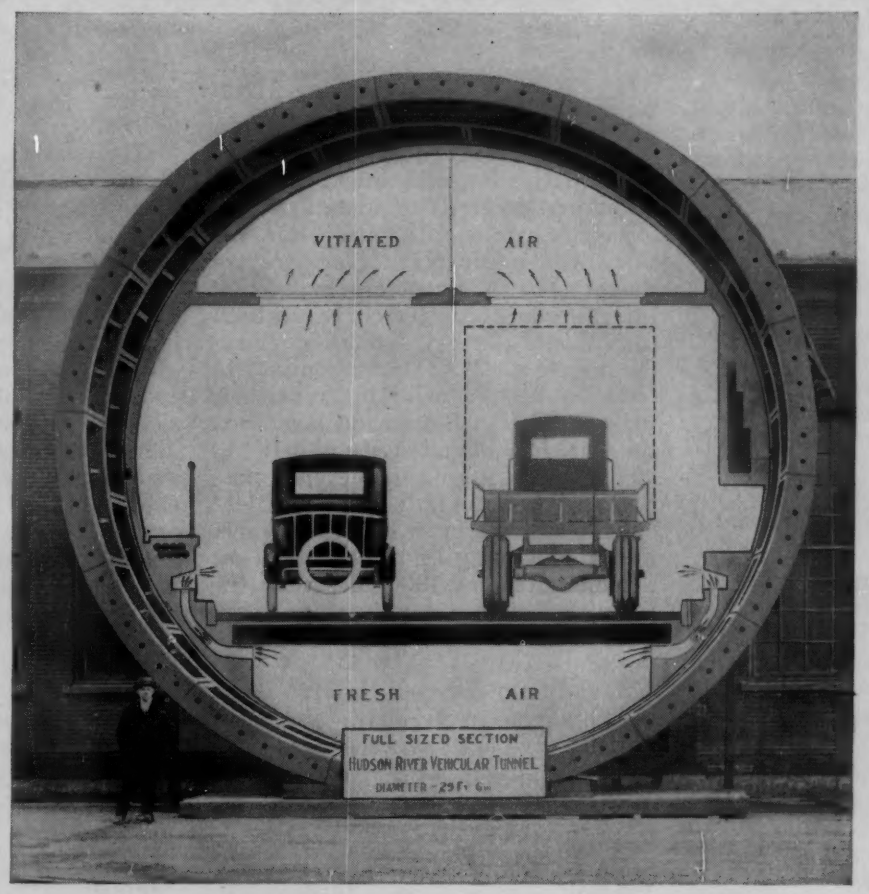

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This is a type of engineering undertaking with which young men in an organization of the size of Westinghouse frequently are brought into intimate contact. Opportunities to work on the stupendous, the never-before-undertaken, are not rare here. Hence young men of capacity, of enterprise, of genius, find much to challenge their imaginations and abilities.

, , ,

A battery of 56 fans driven by Westinghouse motors pump fresh air into, and foul air out of, the Holland Tunnel. Twenty-eight more Westinghouse-motored fans are a reserve. Westinghouse planned the lighting system in the tunnel; also the system of remote control.

Westinghouse

Dust Explosions

(*Continued from page 362*)

rolls and almost all types of pulverizing equipment due to sparks from foreign material. In the heating equipment used in drying, reacting, and energizing processes, explosions have also taken place.

Ignition Sources

Since the ignition sources of explosive dusts are about the same as those of explosive gases, a readily accepted theory would be that any source which will ignite explosive gases will readily ignite explosive dusts. This would include matches, open flames, electric sparks, fires and similar causes of ignition.

The relative degree of fineness of a dust seems to be one of the principal factors to consider in determining the explosibility of a dust. It is believed that the degree of fineness determines the rate of flame propagation through the dust cloud.

The industries in which combustible dusts are produced during operating processes should recognize the hazard of dust explosions and adopt methods of control and prevention.

The Transmission of Heat by Gas Radiation

(*Continued from page 356*)

spect to temperature,¶ an emissivity for a given gas shape may be determined arbitrarily to fit over a given temperature range, just as the radiation equation for solids may be thrown into a first-power-of-temperature form for combination with convection coefficients over given temperature ranges. For the purpose of expediting this procedure a dotted curve has been drawn on Figures 1 and 2 expressing the value of $Q/A\theta$ corresponding to emission from a solid in accordance with the Stefan-Boltzmann law when the solid has an emissivity of 0.1. As an example of use of this curve, suppose it be desired to find the equivalent emissivity for a layer of CO_2 two feet thick, containing 10 per cent CO_2, at a temperature of 1800° F., when the receiving surface temperature is at 700° F. The product term PL = 0.2, for which value $C_{1800} = 3450$, $C_{700} = 325$, and their difference is 3125 B.t.u. per square foot per hour. From the dotted curve a 10 per cent black-body would radiate $4500 - 310 = 4190$. Then the equivalent black-body coefficient of the gas is $0.10 \times 3125/4190 = 0.075$. It should be remembered that this is purely an arbitrary procedure, and that the value 0.075 is applicable only over a certain temperature range and for a fixed gas composition.

Limitations of space prevent any illustrative examples being given to indicate the use of Figures 1, 2 and 3, Table I, and equations 3 and 4. It should be pointed out, however, that since this type of heat transmission differs from heat transmission by convection and conduction in not being expressible in the form of an equation giving the functional relation of T and C or W, a number of problems involve a short trial-and-error solution. A typical problem requiring this type of solution would be one in which it is required that the temperature at the exit be found, for a gas passing through a duct when the initial temperature of the gas, the shape of the duct, the surface, and the temperature are given. Illustrative problems are given elsewhere. ‡§

¶ Over a short temperature range, C or W may be expressed satisfactorily as a power function of T, but the power varies with the temperature range from 4 at low temperatures to 2.5 at high ones, and varies also with the value of PL.

‡ H. C. Hottel, Trans. Am. Inst. of Chem. Eng. (1927).
§ H. C. Hottel, Ind. and Eng. Chem. *19* (1927), 888.

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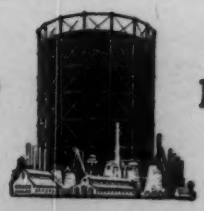
YOU CAN DO IT  BETTER WITH GAS

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The Tech Engineering News

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Pharaoh Wrote Few Letters

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And since the discovery of the tomb of Tutankhamen, tourists have multiplied, impressions have been voluminous, and the mails have increased enormously. "Of course, you can't imagine it without being here, but I simply must tell you about....." And so on.

It is very lucky for the correspondents that with her wonders of antiquity, Egypt did not also inherit the ancient postal system. Only the Pharaohs and the great officers of state could indulge in the luxury of corresponding with a foreign country—and a letter from the King of Egypt to the King of Babylon might take months in transit. Some of these royal letters have come down to us. They are very long, full of elaborate salutations and important news—as if their writers considered their composition the event of a season.

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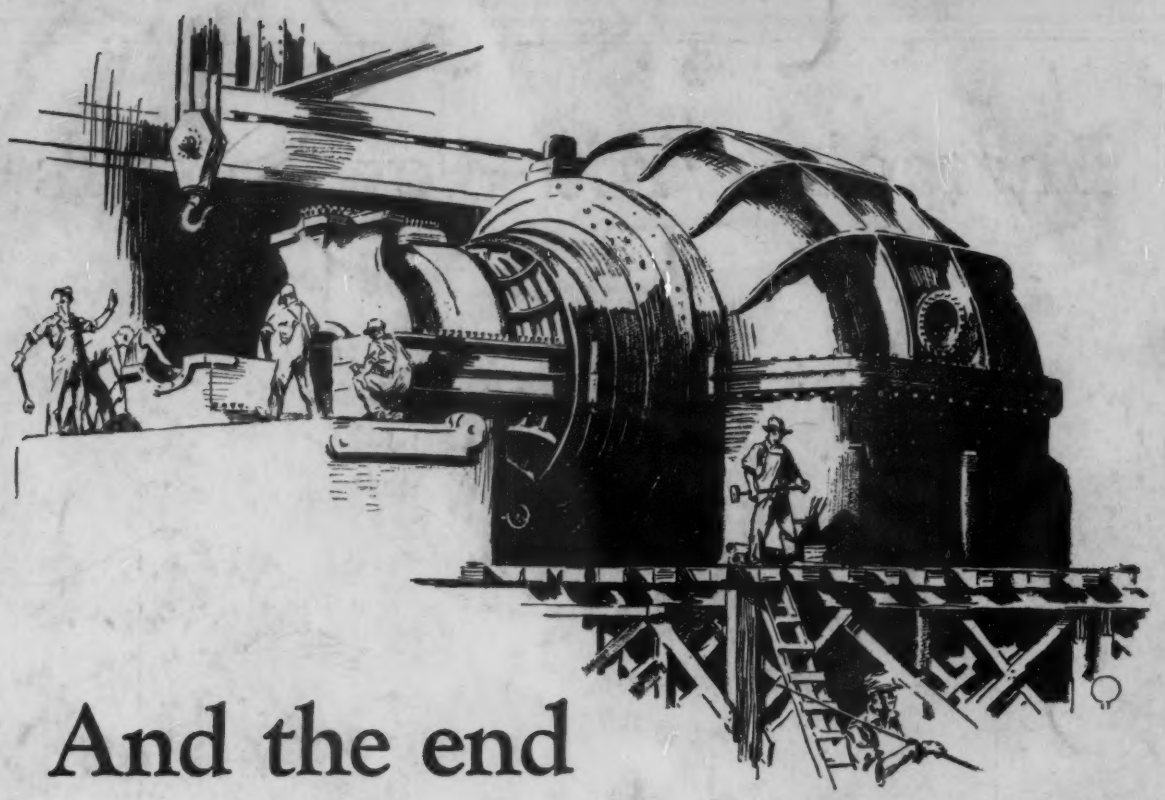

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